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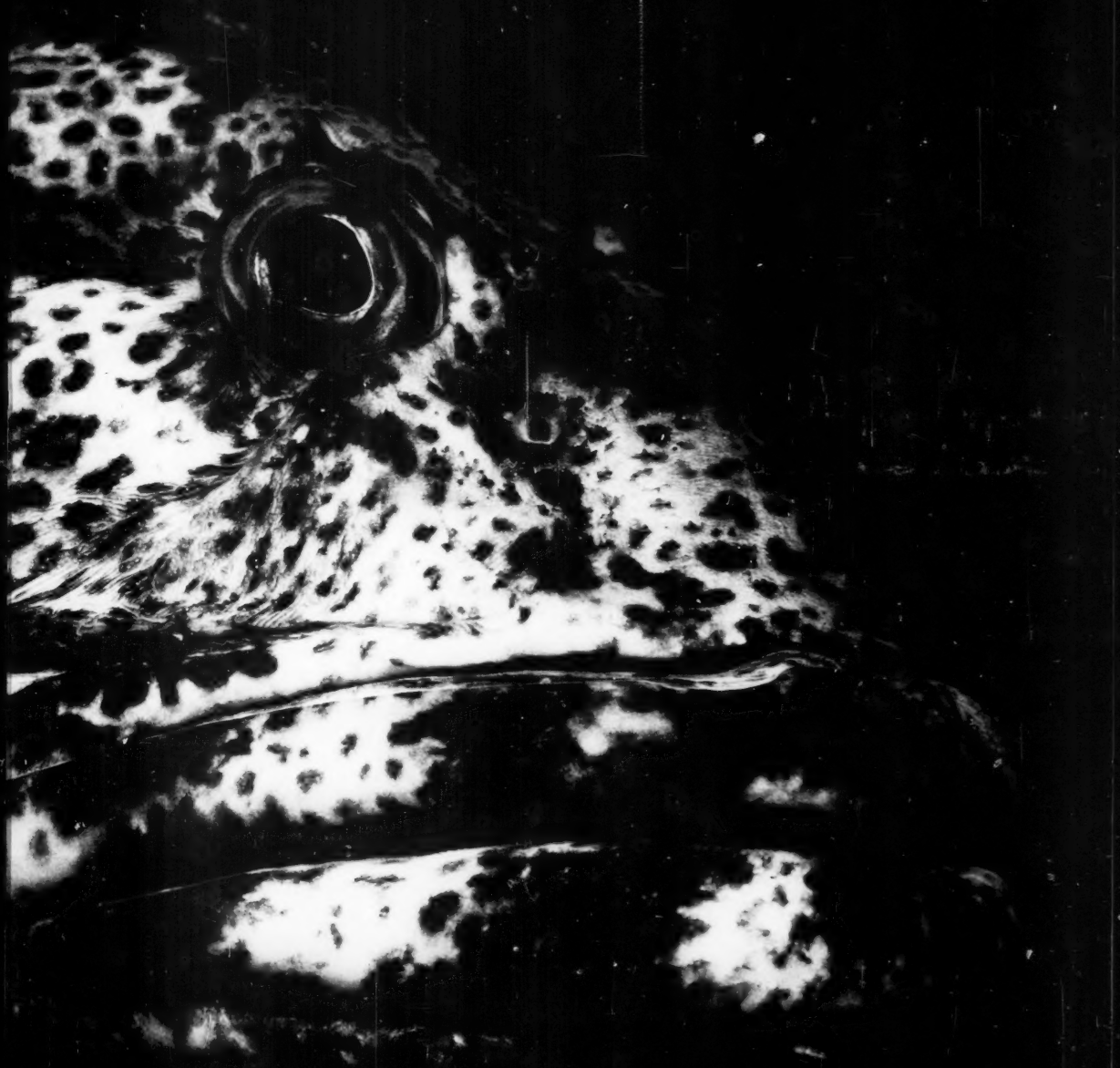
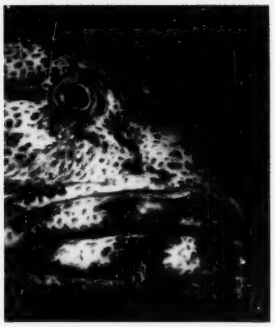


Marine Fisheries REVIEW



On the cover: The lingcod, *Ophiodon elongatus*, is one of many species of fish examined for chlorinated hydrocarbons in the article beginning on page 1. Photograph courtesy of Louis Barr, Auke Bay, Alaska.

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Chlorinated Hydrocarbon Levels in Fishes and Shellfishes of the Northeastern Pacific Ocean, Including the Hawaiian Islands

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*ABSTRACT—We analyzed 39 species of fishes, 6 species of shellfishes, a sea cucumber (*Parastichopus californicus*), and an euphausid, from marine waters off California, Oregon, Washington, British Columbia, Alaska, and Hawaii for ΣDDT (1,1, 1-trichloro-2,2-bis(p-chlorophenyl)ethane, DDT, and its metabolites 1,1-dichloro-2, 2-bis(p-chlorophenyl)ethylene, DDE, and 1,1-dichloro-2,2-bis(p-chlorophenyl)ethane, TDE) and PCB (polychlorinated biphenyls). We also analyzed a few samples of fish eggs, liver, oil, and meal. Finfishes from the northeastern Pacific Ocean rarely contained chlorinated hydrocarbons in excess of 1 ppm; shellfishes never exceeded 0.5 ppm. Often samples did not contain quantifiable amounts of TDE, DDT, or PCB. Chlorinated hydrocarbon levels increased gradually going southward from Alaska to southern California, but the highest levels were associated with point sources of pollution, such as ΣDDT around the Los Angeles County sewer outfalls and PCB from the Duwamish River in the Elliott Bay section of the Seattle, Wash., harbor. The southward geographical gradient was especially steep in sablefish,* Anoplopoma fimbria, *which contained noticeably higher levels of ΣDDT than other species of fishes collected in the same area. Except for sablefish, ΣDDT levels in edible tissue exceeded the U.S. Food and Drug Administration (FDA) guideline of 5 ppm only in certain fishes taken in the vicinity of Los Angeles. Only in goatfish,* Mulloidichthys auriflamma, *from Hawaii did the mean level of PCB exceed the proposed FDA guideline of 2 ppm, but not the current one, 5 ppm. In a few cases length, weight, age, or lipid correlated with chlorinated hydrocarbon content, but frequently contaminant levels had no relationship to physical measurements. In contrast, correlations were often significant between chlorinated hydrocarbons, such as DDE and ΣDDT or ΣDDT and PCB (P = 0.05).*

Introduction

Reports of excessive amounts of chlorinated hydrocarbons in fishery products have threatened the utilization by humans of the vast protein resources in the sea. Chlorinated hydrocarbons from both agricultural and industrial chemicals have been found repeatedly in marine organisms throughout the world (Risebrough et al., 1968, 1976; Bowes and Jonkel, 1975). Insecticides, such as DDT[1] and dieldrin, were the subject of earlier reports on estuarine and marine animals from the northeastern Pacific Ocean (Modin, 1969; Earnest and Benville, 1971; Duke and Wilson, 1971). Levels of ΣDDT exceeding the U.S. Food and Drug Administration action level (5 ppm) were found in fish from central California (Shaw, 1972).

Although the obvious source of pollution would have been agricultural run-off, the principal source was industrial waste disposal. In March 1970, Montrose Chemical Corporation[2] was dumping 290 kg/day of ΣDDT into the Los Angeles (Calif.) County sewer system (Burnett, 1971). As a point of comparison, the San Francisco Bay Delta system, which drains the vast agricultural regions of the Sacramento and San Joaquin River valleys, in 1965 released 8 kg/day ΣDDT into the Pacific Ocean.[3] In the same period before DDT usage declined, the Mississippi River, which receives the run-off from 40 percent of the land mass of the conterminous United States, introduced less than 25 kg/day ΣDDT into the Gulf of Mexico (Butler, 1969). The effluent from the Montrose plant by 1971 had produced a 300 t reservoir of ΣDDT, which extended over an area of 911 nmi^2 surrounding the Los Angeles County sewer outfalls at Whites Point (MacGregor, 1976). After dumping stopped in March 1970, levels of ΣDDT in the marine environment off southern California decreased in areas more removed from the Whites Point sewer outfalls (Anderson et al., 1975), but did not disappear entirely (Anderson et al., 1977). In the vicinity of the outfalls, however, ΣDDT levels in Dover sole did not change in the interval between 1971-72 and 1974-75 (Young et al., 1977; McDermott-Ehrlich et al., 1978).

More recently, a second type of chlorinated hydrocarbon, PCB, surfaced as a contaminant in the aquatic environment. PCB's are industrial chemicals formerly used in electrical equipment, protective coatings, and carbonless carbon paper. Although mainly a problem in freshwater fisher-

[1]Abbreviations used in this manuscript: DDE = 1,1-dichloro-2,2-bis(*p*-chlorophenyl)ethylene; DDT = 1,1,1-trichloro-2,2-bis(*p*-chlorophenyl) ethane; PCB = polychlorinated biphenyls; ΣDDT = DDT and its metabolites DDE and TDE; TDE = 1,1-dichloro-2,2-bis(*p*-chlorophenyl)ethane.

[2]Mention of trade names, products, or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

[3]Southern California Coastal Water Research Project. 1973. Chlorinated hydrocarbons in intertidal organisms of the bight. *In* The ecology of the Southern California Bight: Implications for water quality management, section 8.5.2, p. 307-309. Southern California Coastal Water Research Project, El Segundo, CA 90245.

ies, PCB's are also a concern in species such as striped bass in the eastern United States, Dover sole from around Los Angeles (McDermott-Ehrlich et al., 1978), fishes from areas of unusual PCB pollution, such as the Duwamish River in Seattle, Wash.,[4] juvenile estuarine fishes (Butler and Schutzmann, 1978), and fish livers.[5]

Most previously published data dealing with chlorinated hydrocarbons in marine life of the northeastern Pacific have come from southern California, an area unrepresentative of the northeastern Pacific Ocean as a whole. Not only were the amounts of contaminants entering that environment unusually large, but the means of removing them were unusually small. Because of the very low rainfall, the sewers in the area represent the major "rivers." The sewer effluent provides only a limited source of water for dilution and silt for burial. Under more favorable circumstances, dispersion of both PCB and ΣDDT does occur. In spite of the intensive agricultural activity of the Sacramento and San Joaquin valleys, marine organisms from around San Francisco Bay contained much lower ΣDDT levels than those from the Los Angeles area (Modin, 1969), apparently because of tidal flushing and the continuous deposition of silt. Farther north along the coast, marine animals in the Strait of Georgia contained much lower levels of chlorinated hydrocarbons than those caught near the urban environment of Vancouver, British Columbia (Albright et al., 1975). Fishes and shellfishes from marine waters of Oregon, Washington, and British Columbia contained very low levels of ΣDDT (Stout, 1968).

Although the data in the literature included mainly atypical samples, the safety of marine fishery products to consumers was questioned. Information about typical commercial and sport fisheries was unavailable. Data on chlorinated hydrocarbons in the edible tissues of marine animals of the northeastern Pacific Ocean were needed. To provide that information, we have determined the concentration of ΣDDT and PCB in 45 species of fishes and shellfishes of both sport and commercial importance from marine waters of California, Oregon, Washington, British Columbia, Alaska, and Hawaii. We have included samples of the same species from several geographical areas and from highly polluted as well as relatively clean sites. In most cases, the edible portion (flesh) was analyzed and in a few cases eggs, liver, meal, and oil, in order to expand our information about these fishery products.

Methods

Marine animals (Table 1) were obtained from a variety of sources including research vessels, commercial fishermen, and fish processors. To prevent contamination, specimens were immediately wrapped in new aluminum foil. Unless they could be processed within a day of receipt, specimens were frozen immediately and held at −18°C. Unless specified, samples consisted of the edible portion of the animal: Whole, skinless fillets of fish; drained, shucked oysters and mussels; peeled shrimp (tail meat); and whole squid including beak. Only small portions of halibut, salmon, and tuna were supplied in some cases: A steak, flesh from the nape of the neck, a portion of the light flesh. When available, whole salmon steaks were analyzed (i.e., flesh with skin, fat, and bones) because the skin and fat are often consumed. The choice of species and sites sometimes depended on the availability of specimens from other projects rather than the specific design of this study. Samples of fish liver, eggs, meal, and oil, as well as all shellfish, were analyzed as composites. Many of the samples of edible tissue of finfish were also analyzed as composites of equal-weight portions of ground flesh of individual fish. Shrimp were cooked in order to expedite removal from the shell; all other samples were raw. The tissues were ground and mixed thoroughly to obtain homogeneous samples, which were stored in aluminum or glass containers at −18°C until analysis.

Chlorinated hydrocarbon analysis was evolving during the course of these analyses. For a few of the earlier samples, the AOAC method for determination of chlorinated pesticides in nonfatty foods (Horowitz, 1970) was used; the sample size was adjusted to limit the oil content to 2 g, and water was added to make a total water volume

Table 1.—Marine animals analyzed for chlorinated hydrocarbons, northeastern Pacific Ocean.

Common name	Scientific name
Finfish	
Albacore	*Thunnus alalunga*
Anchovy, northern	*Engraulis mordax*
Bass, striped	*Morone saxatilis*
Bocaccio	*Sebastes paucispinis*
Bonito, Pacific	*Sarda chiliensis*
Cod, Pacific	*Gadus macrocephalus*
Croaker, white	*Genyonemus lineatus*
Goatfish	*Mulloidichthys auriflamma*
Halibut, Pacific	*Hippoglossus stenolepis*
Herring, Pacific	*Clupea harengus pallasi*
Lingcod	*Ophiodon elongatus*
Mackerel, jack	*Trachurus symmetricus*
Marlin, blue	*Makaira nigricans*
Moano	*Parupeneus multifasciatus*
Rockfish, blue	*Sebastes mystinus*
Rockfish, rosy	*Sebastes rosaceus*
Rockfish, species unknown	*Sebastes* spp.
Rockfish, starry	*Sebastes constellatus*
Rockfish, vermilion	*Sebastes miniatus*
Sablefish	*Anoplopoma fimbria*
Salmon, chinook	*Oncorhynchus tshawytscha*
Salmon, chum	*Oncorhynchus keta*
Salmon, coho	*Oncorhynchus kisutch*
Salmon, pink	*Oncorhynchus gorbuscha*
Salmon, sockeye	*Oncorhynchus nerka*
Sardine, Pacific	*Sardinops sagax*
Saury, Pacific	*Cololabis saira*
Scad, bigeye	*Selar crumenophthalmus*
Scad, mackerel	*Decapterus pinnulatus*
Scorpionfish, California	*Scorpaena guttata*
Sole, Dover	*Microstomus pacificus*
Sole, English	*Parophrys vetulus*
Sole, rex	*Glyptocephalus zachirus*
Sole, sand	*Psettichthys melanostictus*
Treefish	*Sebastes serriceps*
Tuna, bigeye	*Thunnus obesus*
Tuna, yellowfin	*Thunnus albacares*
Wahoo	*Acanthocybium solanderi*
Whiting, Pacific[1]	*Merluccius productus*
Shellfish, Plankton, and Sea Cucumber	
Euphausid (plankton)	Euphausiacea
Mussel	*Mytilus edulis*
Oyster, Pacific	*Crassostrea gigas*
Sea cucumber	*Parastichopus californicus*
Shrimp, Alaska pink	*Pandalus borealis*
Shrimp, Oregon pink	*Pandalus jordani*
Shrimp, spot	*Pandalus platyceros*
Squid	*Loligo opalescens*

[1]Formerly known as Pacific hake.

[4]Stout, V. F., and L. G. Lewis. 1977. Appendix B: Role of disposal of PCB-contaminated sediment in the accumulation of PCB's by marine animals. Aquatic disposal field investigations, Duwamish Waterway disposal site, Puget Sound, Wash. Environmental Effects Laboratory, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Miss.

[5]P. A. Butler. EPA-NOAA Fish Monitoring Program: Pacific Coast, Gulf Breeze, Fla., private commun. March 1975.

of 80 ml. In most cases, however, extracts were prepared by the procedure of Reinert (1970), because it gave cleaner extracts of marine fishery samples (Stout and Beezhold, 1979). Samples were extracted with propanol-2/benzene (1:1), and the extracted materials transferred to hexane by repeated codistillation of the propanol-2, benzene, and water with hexane. One aliquot of the hexane extract was evaporated to minimum weight for determination of the lipid content. Another aliquot was cleaned up on Florisil. PCB's were separated from TDE, DDT, and most of the DDE on activated silica gel (Snyder and Reinert, 1971), which also separates the interfering hydrocarbons, phenanthrene, fluoranthrene, and pyrene from the PCB (Zitko, 1978). At least 90 percent of the PCB was contained in the pentane fraction, which also contained part of the DDE. The rest of the DDE and all of the TDE and DDT were eluted in the benzene fraction. DDE was quantified by summing the amount in both fractions. In earlier samples, PCB's were not separated from DDT and its metabolites. The details of our procedures were published previously (Stout and Beezhold, 1979). Blanks carried through the whole procedures showed no chromatographic peaks which interfered with quantitation of the chlorinated hydrocarbons.

Extracts were quantitated by electron-capture gas chromatography. A Varian 600 C gas chromatograph with a titanium tritide detector was fitted with a 1.5 m (5 foot) × 0.32 cm (0.125 inch) outside diameter glass column containing a mixture of equal parts of 15 percent QF-1 on 800-100 mesh Gas-Chrom Q and 10 percent DC-200 on the same support (Burke and Holswade, 1966). Reference standards of *p,p'*-DDE, *p,p'*-TDE, and *p,p'*-DDT were obtained from the U.S. Environmental Protection Agency, Health Effects Research Laboratory, Research Triangle Park, N.C. They were at least 99 percent pure. Aroclor 1254 obtained from the Monsanto Company, St. Louis, Mo., was the standard for the PCB, because the residues in the fish matched this Aroclor most closely. Standard curves of peak height versus concentration were used to determine the concentrations of components in the extracts. The sensitivity throughout each run was assured by frequent injections of standard solutions.

In most samples, the PCB's were quantitated by summing the peak heights corresponding to the five major peaks in Aroclor 1254 after omitting the peak with a retention time similar to that of *p,p'*-DDE (Stout, 1980). The PCB in a few samples were quantified by including the contribution of four additional peaks following the major peaks of Aroclor 1254. In those cases, standard curves also included the sum of the heights of those peaks. This method was used for samples in a study of the accumulation of PCB from dumped dredge spoils (footnote 4) to compensate for the presence of PCB similar to Aroclor 1260. This simplified method accounted for approximately 90 percent of the PCB indicated by a mixed standard of Aroclors 1254 and 1260. The presence of the more highly chlorinated PCB is indicated in the tables and text. The ΣDDT content of these samples was quite low; to improve the accuracy of PCB analysis, DDT/PCB separation was omitted. Consequently, only the major component, DDE, was quantified. The very small amounts of TDE and DDT were obscured by PCB peaks and were not measurable. In every sample, a correction to the DDE concentration in the pentane fraction was made to compensate for the component of PCB which overlapped with the DDE peak. The correction was based on the concentration of PCB in the same pentane fraction, as described by Stout (1980).

The quantifiable limit was 0.01 ppm for DDE, TDE, and DDT, and about 0.05 ppm for PCB depending on daily sensitivity. When the limit differed from specified, it was indicated in the tables. The mean coefficient of variation for samples analyzed in duplicate was 11 percent. The average recovery of spiked standards was 85 percent. The values reported were not corrected for recovery. Residue values were calculated on the basis of micrograms chlorinated hydrocarbon per gram wet tissue or parts per million (ppm).

Results and Discussion

Continental United States and British Columbia

Shellfishes, Plankton, and Sea Cucumbers

Mollusks have been used as indicators of chlorinated hydrocarbon pollution (Butler, 1973; Goldberg et al., 1978), because they accumulate and depurate these substances readily in response to changing concentration in the environment. Our data for shellfishes present a clear picture of the low levels of these pollutants in several coastal areas of the northeastern Pacific Ocean. In most cases, the values were below the quantifiable limit, 0.01 ppm ΣDDT and 0.05 ppm PCB. Butler (1973), in his massive study of oysters, rarely found quantifiable amounts of chlorinated hydrocarbons in the marine waters of Washington. Even in southern California where previous workers found elevated levels of ΣDDT and PCB in fishes, the levels in squid were low, 0.018 ppm ΣDDT and <0.1 ppm PCB (Table 2).

Limited dilution of pollutant-laden run-off may account for the low but measurable levels of PCB in marine animals from Puget Sound and Hood Canal. The land mass of the Olympic Peninsula restricts the full impact of oceanic tidal flushing in these inland waters. Sea cucumbers from Agate Passage, Wash., away from concentrated urban development but popular for small boats (sources of PCB contamination), contained the lowest quantifiable level of PCB, 0.05 ppm. Mussels from Manchester, Wash., contained 0.09 ppm PCB. The water in that area comes from upwellings from the depths of Puget Sound, and it is thought to be unusually free from human pollution. The mussels, however, were collected from piers which had been treated with antifouling material which may have contained PCB. Euphausids, zooplankton common in Puget Sound, contained 0.20 ppm PCB. Whole spot shrimp from Whitney Point, Wash., on Hood Canal contained 0.17 ppm PCB. That elevated level may result from the inclusion

Table 2.—ΣDDT and polychlorinated biphenyls in shellfishes, plankton, and sea cucumbers from the northeastern Pacific Ocean.

Species	Date of collection (mo/yr)	Location	No. of animals[1]	Lipid content (%)	Mean total length (cm)	Mean weight (g)	Chlorinated hydrocarbon content (ppm) DDE ppm	TDE ppm	DDT ppm	ΣDDT ppm	PCB[2] ppm
Euphausids[3]	2/72	Kayak Pt., Wash.	[4]				0.009	0.007	0.014	0.030	0.20
Mussel	3/76	Mukilteo, Wash.	120	0.9	4.3	6.3	0.008	n.a.	n.a.		[5]0.12
	9/70	Manchester, Wash.	75	1.41	5.8	18.9	n.d.	n.d.	n.d.	n.d.	n.a.
	9/72	Manchester, Wash.	12		5.6	15.7	n.d.	n.d.	n.d.	n.d.	0.09
Oysters	8/75	Liberty Bay, Wash.	6		13.1	39.0	n.d.	n.d.	n.d.	n.d.	<0.11
Sea cucumbers[3]	3/76	Agate Passage, Wash.	12	0.5		342	n.d.	n.d.	n.d.	n.d.	0.05
Shrimp, Alaska pink[3]	2/76	Seattle harbor, Wash.[6]	84	1.5		6.2	n.d.	n.a.	n.a.		[5]0.39
Shrimp, Oregon pink	5/70	Westport, Wash.	50			4.9	n.d.	n.d.	n.d.	n.d.	n.a.
[3]	4-12/76	Seattle harbor, Wash.	98	1.7		4.0	n.d.	n.a.	n.a.		[5]0.43
	7/70	Astoria Canyon, Oreg.	50	1.0		5.6	n.d.	n.d.	n.d.	n.d.	n.a.
	5/70	Garibaldi Pt., Oreg.	50	1.4		4.1	n.d.	n.d.	n.d.	n.d.	n.a.
	7/70	Tillamook Head, Oreg.	50	0.7		5.7	n.d.	n.d.	n.d.	n.d.	n.a.
Shrimp, spot[3]	2/76	Whitney Point, Wash.	40	1.5		23.1	n.d.	n.a.	n.a.		[5]0.17
Squid[3]	7/72	Monterey Bay, Calif.	10	1.9	14.8	78.2	n.d.	n.d.	n.d.	n.d.	<0.1
[3]	3/71	San Pedro, Calif.	11		12.7	36.4	0.018	n.d.	n.d.	0.018	n.a.

Note: n.a. = not analyzed; n.d. = not detected.
[1]Edible tissue analyzed as a composite.
[2]Aroclor 1254 used as standard.
[3]Whole, raw.
[4]Two 10-g samples.
[5]Aroclor 1254 and 1260.
[6]Elliott Bay. The Duwamish River, known to be heavily polluted with PCB (Butler and Schutzmann, 1978), flows into Elliott Bay.

of the nonedible parts of the animal, especially the hepatopancreas, in the sample.

The highest levels of PCB were found in Elliott Bay, the main deep-water harbor area of Seattle, Wash. Alaska pink shrimp contained 0.39 ppm PCB and Oregon pink shrimp, 0.43 ppm PCB (Table 2). The Duwamish River, which flows into Elliott Bay, was known to be polluted with PCB at least as early as 1972 (Butler and Schutzmann, 1978). Sources of this pollution have not been identified, but both distributors and users of these chemicals have facilities along the river.

Fishes

General Distribution of ΣDDT and PCB. Early work focused on acquiring a broad spectrum of data, to obtain an overview of the chlorinated hydrocarbon picture in marine fishes of the northeastern Pacific Ocean. Many samples were analyzed as composites of several animals. Later on, more individual fish were tested. In all, about 40 percent of the data on fishes was derived from analyses of individual fish.

Instead of the anticipated normal distribution, the chlorinated hydrocarbon levels varied widely between individual fish in a single catch. Often one or two fish had markedly higher levels than the others. Frequently the range of concentrations of pollutants was extremely wide. The ratio of highest to lowest concentration among fish in a single sample reached 92 for ΣDDT and 24 for PCB (Fig. 1). This variability was not related just to size of fish nor simultaneous exposure to both pollutants, as illustrated by a catch of 10 striped bass from the Sacramento River at Clarksberg, Calif. (The striped bass is anadromous.) The heaviest fish, 20.5

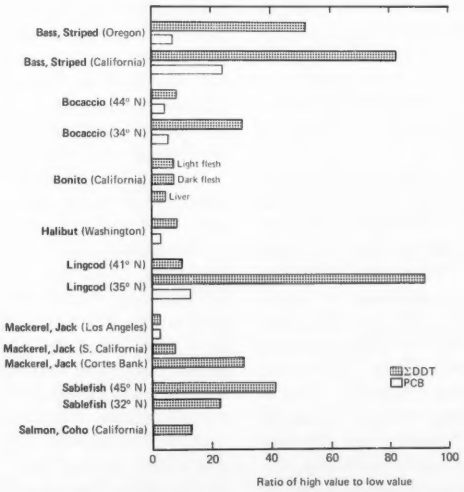

Figure 1.—Variability in chlorinated hydrocarbon level among individual northeastern Pacific fishes in a single catch: ratio of highest value to lowest value.

Table 3.—Coefficients of variation of the physical data, ΣDDT and polychlorinated biphenyls in fish analyzed individually, northeastern Pacific Ocean.

Species[1]	Location	Coefficient of variation (%)							
		Lipid	Length	Weight	DDE	TDE	DDT	ΣDDT	PCB
Albacore	Northern Calif.	49.3	8.5	23.9	58.8	n.c.	n.c.	[2]	n.c.
	33°00′N 135°00′W	45.0	13.6	29.7	38.5	n.c.	n.c.	[2]	n.c.
Bass, striped	Umpqua River, Oreg.	58.6	23.5	75.2	86.2	86.4	82.1	86.1	65.2
	Clarksberg, Calif.	81.8	24.7	72.9	220	166	127	200	86.6
Bocaccio	44°42′N 124°24′W	53.2	6.8	20.9	65.5	82.4	75.9	67.6	62.8
	34°06′N 119°24′W	38.1	22.0	56.6	118	110	126	118	69.8
Bonito	Ventura, Calif.	37.3	3.3	7.1	87.6	85.5	85.7	86.1	n.a.
Halibut, Pacific	Kodiak, Alaska	86.5	32.6	92.6	75.0	n.c.	n.c.	[2]	53.1
	British Columbia	68.8	14.1	43.0	88.9	n.c.	n.c.	[2]	n.c.
	S. of Willapa Bay, Wash.	120	23.1	63.2	55.6	42.9	90.0	66.3	36.2
Lingcod	41°20′N 124°10′W	87.7	18.1	54.6	77.3	n.c.	n.c.	[2]	n.c.
	35°35′N 121°16′W	148	16.9	53.3	219	177	247	220	105
Mackerel, jack	Near Los Angeles Harbor, Calif.	27.5	5.4	13.5	34.3	34.3	40.3	33.3	31.7
	Southern Calif.[3]	45.7	n.a.	23.3	67.9	95.0	109	74.9	n.a.
	Cortes Bank, Calif.	29.0	3.9	10.6	54.8	39.5	27.4	53.2	18.2
Sablefish[4]	45°23′N 124°45′W	n.a.	13.5	31.5	178	131	115	169	n.a.
	32°26′N 117°33′W	27.6	6.1	21.4	77.8	84.7	82.0	76.2	n.a.
Salmon, coho	Point Reyes, Calif.	51.3	13.5	53.2	113	103	53.1	107	n.c.
Mean		62.1	14.7	41.5	95.3	95.2	97.0	104.4	58.7
Standard deviation		33.6	8.5	24.9	55.8	44.0	54.6	57.5	27.4

Note: n.c. = not calculable because substance not detected in most specimens; n.a. = not analyzed.
[1]For further details about date of catch, number of fish, etc., see Table 5.
[2]Only quantifiable for DDE.
[3]Catch date 1/70.
[4]Listed in Table 5.

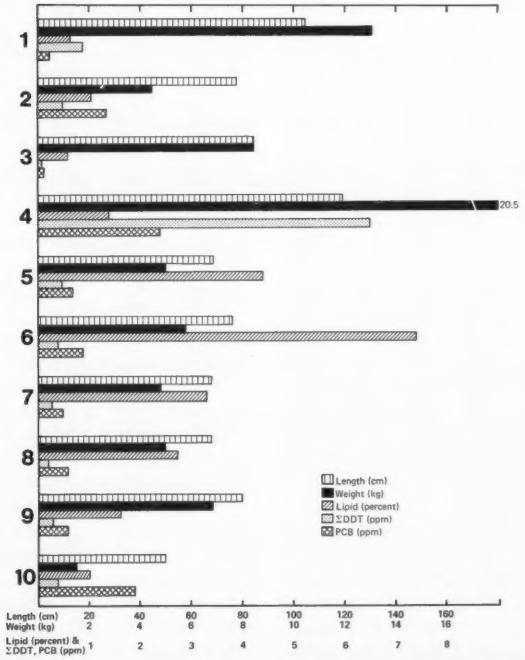

Figure 2.—Variability in length, weight, lipid, ΣDDT, and PCB among 10 striped bass collected near Clarksberg, Calif. (These anadromous fish spawn in the Sacramento River.)

kg, ranked highest in both ΣDDT and PCB content. The lightest fish, 1.5 kg, ranked second highest in PCB content, but only sixth in ΣDDT content. The heaviest fish ranked seventh in lipid content, the lightest fish, fifth. The two lightest fish were males; they ranked second and third in PCB content, third and sixth in ΣDDT content, fifth and eighth in lipid content, and fifth and tenth in length. The fish with the lowest lipid content, 0.6 percent, contained the least ΣDDT and PCB, but the fish with the highest lipid content, 7.4 percent, ranked near the middle in chlorinated hydrocarbon content. The fish with the greatest amounts of ΣDDT and PCB ranked seventh in lipid content (Fig. 2).

How did the fluctuations of all these parameters rank in fishes analyzed individually? Size variations were smallest, variations in PCB and lipid content intermediate, and variations in ΣDDT content highest of all. The means of the coefficients of variation were 14.7 ± 8.5 percent for length, 41.5 ± 24.9 percent for weight, 58.7 ± 27.4 percent for PCB, 62.1 ± 33.6 percent for lipid, 95.3 ± 55.8 percent for DDE, and 104 ± 57.5 percent for ΣDDT (Table 3). The standard errors of the means of DDE, ΣDDT, and PCB are shown in Table 4.

The method for summarizing data was an important issue, because of this great variability in size, lipid, and chlorinated hydrocarbon levels among individual specimens within samples. Some authors (e.g., Butler and Schutzmann, 1978) have reported data on marine organisms in terms of percent positive samples, highest residue level, and mean of positive samples. We felt that this system emphasized positive data, because data for samples without quantifiable residues tended to be obscured. Instead we reported means which included all specimens. Geometric means or medians would have reduced the skew from high outliers and better reflected the contaminant picture in the marine environment. Arithmetic means, on the other hand, could be compared directly with the many data on composite samples, which perforce included high outliers.

Table 4.—ΣDDT and polychlorinated biphenyls in marine fishes from the northeastern Pacific Ocean.

Species	Date of collection (mo/yr)	Location	No. of animals[1]	Lipid content (%)	Mean fork length (cm)	Mean weight (g)	Chlorinated hydrocarbon content (ppm) DDE(SEM)	TDE	DDT	ΣDDT(SEM)	PCB[2](SEM)
Albacore	9/70	Off Grays Harbor, Wash.	7	9.8	66	5,833	0.032	n.d.	0.020	0.052	n.a.
	8/73	Northern Calif.	[3]10	6.8	61	4,849	0.017 (0.003)	n.d.	n.d.	0.017 (0.003)	<0.05(0.003)
	6/73	33°00′ N 135°00′ W	[3]10	3.4	61	3,946	0.013 (0.002)	n.d.	n.d.	0.013 (0.002)	<0.05(0.002)
Anchovy, northern	7/69	Camano Island, Wash.	[4]19		13	15	0.018	0.020	0.012	0.050	n.a.
	9/72	San Pedro Harbor, Calif.	[4]25	11.4	12	15	1.64	0.456	0.074	2.18	0.83
Bass, striped	6/73	Umpqua River, Oreg.	[3]10	2.6	84	9,645	0.058 (0.016)	0.022	0.028	0.108 (0.029)	0.19(0.039)
	6/73	Clarksberg, Calif.	[3]10	2.8	80	7,517	0.742 (0.515)	0.206	0.093	1.04 (0.658)	0.99(0.270)
Bocaccio	6/75	44°42′ N 124°24′ W	[3]10	1.9	73	4,772	0.139 (0.029)	0.017	0.029	0.185 (0.040)	0.14(0.029)
	4/74	34°06′ N 119°24′ W	[3]10	1.2	50	1,519	0.735 (0.274)	0.020	0.042	0.797 (0.298)	0.16(0.035)
	5/70	Santa Monica Bay, Calif.	[5]9	1.4	31	282	9.38	1.02	1.24	11.6	n.a.
	9/70	Santa Monica Bay, Calif.	[5]4	3.8	33	249	6.38	0.76	0.84	7.97	n.a.
	9/70	Santa Monica Bay, Calif.	[5]3	3.0	44	643	25.2	1.61	2.12	28.9	n.a.
Bonito, Pacific	3/71	Ventura, Calif.	[3]10	8.0	60	3,030	6.19 (1.71)	1.01	0.889	8.08 (2.20)	n.a.
Cod, Pacific	9/70	Vancouver Island, B.C.	10	0.5	49	1,349	n.d.	n.d.	n.d.	n.d.	n.a.
Croaker, white	5/70	Oceanside, Calif.	16	0.7	23	161	0.583	<0.04	0.058	0.641	n.a.
Halibut, Pacific	7/71	Kodiak, Alaska	[3]10	2.8	132	42,350	0.008 (0.002)	n.d.	n.d.	0.008 (0.002)	0.05(0.008)
	8/71	British Columbia	[3]10	3.1	101	13,870	0.018 (0.005)	n.d.	n.d.	0.018 (0.005)	<0.08(0.005)
	4/72	S. of Willapa Bay, Wash.	[3]10	4.0	117	24,730	0.072 (0.013)	0.007	0.010	0.089 (0.019)	0.09(0.011)
Herring, Pacific	12/68	Bellingham, Wash.	[4]50				0.043	0.012	0.041	0.097	n.a.
Lingcod	7/73	41°20′ N 124°10′ W	[3]10	1.2	78	5,821	0.088 (0.022)	n.d.	n.d.	0.088 (0.022)	<0.06(0.004)
	4/74	35°35′ N 121°16′ W	[3]10	0.9	69	3,741	0.886 (0.613)	0.044	0.073	0.999 (0.696)	0.20(0.068)
Mackerel, jack	10/69	Long Beach, Calif.	[5]13		29	224	2.34	0.62	0.24	3.21	n.a.
	7/73	Near Los Angeles Harbor, Calif.	[3,5]10	9.9	31	374	2.57 (0.279)	0.394	0.159	3.12 (0.329)	0.92(0.092)
	12/69	Southern Calif.	[5]52			106	0.364	0.049	0.097	0.510	n.a.
	1/70	Southern Calif.	[3,5]25	2.9		248	4.46 (0.606)	0.624	0.618	5.70 (0.854)	n.a.
	6/73	Cortes Bank, Calif.	[3,5]10	4.7	24	163	0.062 (0.011)	0.008	0.007	0.077 (0.013)	<0.08(0.004)
Rockfish, blue	5/70	Farnsworth Bank, Calif.	5	1.8	22	170	0.440	<0.02	0.055	0.495	n.a.
Rockfish, rosy	5/70	Farnsworth Bank, Calif.	16	0.7	16	87	0.283	<0.05	<0.05	0.283	n.a.
Rockfish, unknown	1/70	Cortes Bank, Calif.	10	0.9	24	245	0.123	<0.02	<0.02	0.123	n.a.
Rockfish, starry	5/70	Santa Monica Bay, Calif.	5	1.8	25	294	50.5	3.14	3.64	57.2	n.a.
	9/70	Santa Monica Bay, Calif.	2	2.1	22	148	67.4	3.26	5.58	76.3	n.a.
	5/70	Farnsworth Bank, Calif.	13	0.9	19	104	0.283	<0.04	<0.04	0.283	n.a.
Rockfish, vermilion	5/70	Santa Monica Bay, Calif.	10	2.2	31	533	14.9	[6]	1.12	16.0	n.a.
	9/70	Santa Monica Bay, Calif.	2	3.5	24	297	39.6	3.20	3.68	46.5	n.a.
	9/70	Santa Monica Bay, Calif.	1	4.2	34	621	59.5	4.85	4.72	69.1	n.a.
Sablefish[7]											
Salmon, chinook	7/70	Manchester, Wash.[8]	[5]25	3.4	11	16	0.075	0.007	0.037	0.118	n.a.
	9/70	Manchester, Wash.[8]	[5]25	2.4	13	34	0.078	<0.015	0.037	0.115	n.a.
	9/74	Westport, Wash.	[9]1				0.075	<0.02	<0.02	0.075	0.24
	5/73	Columbia River, Oreg.	[3]2	11.8	74	10,669	0.189	0.047	0.033	0.270	0.26
	8/69	Jones Beach, Oreg.	[6]25		[10]	[10]	0.054	0.038	0.043	0.134	n.a.
	8/74	Pt. Reyes, Calif.	[3]2	6.8	67	4,953	0.069	0.013	0.009	0.091	0.09
Salmon, chum	6/73	Puget Sound, Wash.	[3]2	7.4	56	2,156	0.006	n.d.	n.d.	0.006	<0.04
Salmon, coho	7/70	Manchester, Wash.[8]	[5]1	8.2	43	1,150	0.090	0.015	0.040	0.144	n.a.
	9/70	Manchester, Wash.[8]	[5]15	2.9	23		0.060	n.d.	0.038	0.098	n.a.
	11/75	Auburn, Wash.	[9]10	3.1	60	2,565	0.023	0.006	0.005	0.034	0.24
	5/73	Columbia River, Oreg.	[3]2	6.1	54	3,100	0.027	n.d.	n.d.	0.027	<0.06
	8/74	Pt. Reyes, Calif.	[3]5	5.4	61	4,067	0.046 (0.023)	0.009	0.006	0.061 (0.030)	<0.09(0.018)
Salmon, pink	6/73	Puget Sound, Wash.	[3]2	9.6	55	2,270	0.009	n.d.	n.d.	0.009	<0.05
Salmon, sockeye	8/70	Seattle, Wash.[11]	[9]9	9.5			0.015	0.010	0.015	0.039	n.a.
	6/73	Puget Sound, Wash.	[3]2	9.4	56	2,384	0.007	n.d.	n.d.	0.007	<0.04
Saury, Pacific	8/70	Off Grays Harbor, Wash.	[5]75	6.3	50		0.020	0.004	0.006	0.030	n.a.
	67	La Jolla, Calif.	[4]30				n.d.	n.d.	n.d.	n.d.	n.a.
Scorpionfish, California	7/70	Farnsworth Bank, Calif.	10	0.9		378	0.258	<0.015	<0.015	0.258	n.a.
Sole, Dover	7/70	Astoria Canyon, Oreg.	10	0.5	42	688	n.d.	n.d.	n.d.	n.d.	n.a.
	9/70	Astoria, Oreg.	10	0.8	32		n.d.	n.d.	n.d.	n.d.	n.a.
	5/70	Santa Monica Bay, Calif.	13	3.6	24	141	11.6	0.82	0.93	13.3	n.a.
Sole, English	76	Seattle Harbor, Wash.[12]	[4]80	4.0	26	141	0.016	n.a.	n.a.		[13]1.71
	9/70	Astoria, Oreg.	10	1.9	29		0.023	n.d.	n.d.	0.023	n.a.
	5/70	Pt. Loma, Calif.	14	0.8	22		0.653	0.051	0.077	0.781	n.a.
Sole, rex	7/70	Astoria Canyon, Oreg.	10	0.5	30	154	n.d.	n.d.	n.d.	n.d.	n.a.
	9/70	Astoria, Oreg.	10	0.6	28		n.d.	n.d.	n.d.	n.d.	n.a.
Sole, sand	7/70	Astoria, Oreg.	10	0.5	38	608	0.008	n.d.	n.d.	0.008	n.a.
Treefish	5/70	Farnsworth Bank, Calif.	7	0.9	20	146	0.229	<0.04	<0.04	0.229	n.a.
Whiting, Pacific[14]	9/70	Astoria, Oreg.	[4]10	5.2	45		0.070	0.007	0.022	0.100	n.a.

Note: n.d. = not detected; n.a. = not analyzed.
SEM = standard error of the mean (relevant to specimens analyzed individually only).
[1] Fillets analyzed as a composite, except as noted.
[2] Aroclor 1254 used as standard.
[3] Analyzed individually.
[4] Whole.
[5] Whole fish, less head, tail, and viscera.
[6] Interference.
[7] Tabulated separately in Table 5.
[8] Hatchery reared.
[9] Steak.
[10] Fingerlings.
[11] Chittenden Locks.
[12] Elliott Bay. The Duwamish River, known to be heavily polluted with PCB, flows into Elliott Bay.
[13] Aroclor 1254 and 1260.
[14] Formerly known as Pacific hake.

For this reason, arithmetic means were calculated for all parameters in fish analyzed individually.

Marine fishes from the northeastern Pacific Ocean rarely contained chlorinated hydrocarbons in excess of 1 ppm. Samples of fishes often did not contain quantifiable amounts of TDE, DDT, and PCB. A few examples will describe the general picture. Thus, halibut from Alaska, British Columbia, and Washington contained less than 0.1 ppm ΣDDT or PCB. Albacore from Washington and northern California contained similar low levels of these contaminants. No ΣDDT was found in Dover, English, rex, or sand soles from the mouth of the Columbia River. In five species of salmon from Washington, Oregon, and California, the chlorinated hydrocarbon levels were 0.007-0.270 ppm ΣDDT and <0.04-0.26 ppm PCB (Table 4).

The amounts of chlorinated hydrocarbons in marine animals generally reflect the extent to which these compounds occur in marine waters and in the air above. The levels in fishes reflect long-term exposure, since fishes lose these compounds slowly, if at all (Lieb et al., 1974). Our data for both shellfishes and finfishes indicate that in most places north of California, only limited amounts of chlorinated hydrocarbons were ever released into the marine environment of the northeastern Pacific Ocean. These findings are similar to those for the northwestern Atlantic Ocean (Sims et al., 1977; Stout, 1980).

Point Sources of ΣDDT and PCB. Within a single species, chlorinated hydrocarbon levels increased gradually going southward from Alaska to southern California and dramatically from offshore southern California to Los Angeles (Table 4). Burnett (1971) found a similar ΣDDT gradient in the mole crab, *Emerita analoga*, from sites between San Francisco and the U.S.-Mexico border. The maximum levels of chlorinated hydrocarbons were associated with the Whites Point sewer outfalls in Los Angeles County, Calif. Starry rockfish from Santa Monica Bay contained up to 76 ppm ΣDDT in the flesh. Besides living in a heavily contaminated area, rockfish live longer than most fish. The specimens examined in our study were more than 10 years old. The high ΣDDT levels in the fishes of this one specific area indicated that the reservoir of ΣDDT in the marine sediments off Los Angeles contributed much more ΣDDT to marine fishes than past agricultural and domestic applications of the insecticide DDT. Furthermore, anchovies and jack mackerel from the Los Angeles area contained nearly 1 ppm PCB in addition to high levels of ΣDDT (Table 4). The ΣDDT around the sewer outfalls apparently travels a long distance. The Southern California Coastal Water Research Project (footnote 3) reported elevated levels of ΣDDT in the coastal mussel, *Mytilus californianus*, up to 100 km away. In our study, lingcod collected about 270 km to the north at lat. 35°35′N, long. 121°16′W (near Morro Bay, Calif.) contained 1 ppm ΣDDT but substantially less PCB, 0.20 ppm.

Outside of southern California, the areas of notable chlorinated hydrocarbon concentration were the Sacramento River and the Elliott Bay area of Seattle harbor. The Sacramento River receives widespread run-off from urban development and agricultural activities in the Sacramento valley and indirectly via tidal wash, from the region drained by the San Joaquin River. Both ΣDDT and PCB were elevated, 1 ppm each, in striped bass from the Sacramento River. Elliott Bay, as is typical for marine waters of Washington (Butler, 1973), contained little ΣDDT. The maximum concentration in English sole was 0.070 ppm DDE. PCB levels, however, were distinctly elevated. The mean for 80 English sole was 1.71 ppm. Four of 16 composites, each containing 5 fish, had PCB levels above 3 ppm. These data were completely consistent with the known PCB pollution of the Duwamish River, which flows into Elliott Bay. In spite of the PCB reservoir in the Duwamish River (Butler and Schutzmann, 1978; footnote 4), coho salmon, which had migrated upstream through the area to a hatchery at Auburn, Wash., contained only 0.24 ppm PCB compared with <0.05 ppm in fish caught off the Columbia River, an area without known PCB pollution.

The Los Angeles sewer outfalls, Sacramento River, and Elliott Bay represented the exceptions in chlorinated hydrocarbon pollution of marine waters of the northeastern Pacific. All these areas attract sport fisheries, but little commercial fishing. Although localized problems may have existed in other areas, the effects of these sources on marine fishes were detectable only in a few fish.

Sablefish. Outside of the fallout area of point sources of chlorinated hydrocarbon pollution, marine fishes generally did not contain more than 1 ppm ΣDDT. A preliminary analysis of a single sablefish from northern Oregon foretold that sablefish was a unique species in the northeastern Pacific Ocean. That one fish contained 2.92 ppm ΣDDT. Subsequent analyses of 22 individual specimens and 26 composite samples of sablefish, 582 fish in all, showed that they contained unusually high levels of ΣDDT compared with all other species tested. Sablefish from the Bering Sea contained the same amount of ΣDDT, 0.01 ppm, as halibut from Kodiak Island, but five other samples from southeastern Alaska showed consistently higher levels up to a maximum of 0.22 ppm ΣDDT. The geographical ΣDDT gradient was particularly evident in sablefish. Three samples from Washington waters contained a mean of 0.66 ppm ΣDDT, and five samples from Oregon, 0.75 ppm. The highest levels in individual fish from Oregon were 13.4, 12.7, 2.92, and 1.65 ppm. Most samples from California contained more than 1 ppm ΣDDT (Table 5). From Santa Cruz southward, the mean ΣDDT level generally exceeded 5 ppm, a level found in other species only near Los Angeles. In individual sablefish from southern California, the highest concentrations were 20.2, 11.7, 11.5, and 10.1 ppm.

Alongside the steeper southward gradient in ΣDDT levels in sablefish was a similar geographic disparity in the relative contributions of DDT and

Table 5.—DDT and its metabolites in sablefish, *Anoplopoma fimbria*, from the northeastern Pacific Ocean.

Date of collection (mo/yr)	Location	No. of animals[1]	Lipid content (%)	Mean length[2] (cm)	Mean weight[2] (g)	Chlorinated hydrocarbon content (ppm) DDE(SEM)	TDE	DDT	ΣDDT(SEM)
9/71	Bering Sea, Alaska	9	3.4	33	916	0.010	n.d.	n.d.	0.010
3/71	Lisianski Inlet, Alaska	8	5.0	52	1,375	0.030	n.d.	n.d.	0.030
5/72	Betton Island, Alaska	23	18.8	42	2,015	0.133	0.029	0.053	0.215
5/72	Betton Island, Alaska	12	17.6	50	3,610	0.082	0.018	0.042	0.142
3/72	Southeast Alaska	46	11.7	42	1,917	0.061	0.014	0.032	0.107
3/71	Unknown, Alaska	10	21.0	64	3,625	0.074	<0.04	0.049	0.123
3/71	48°21′N 126°01′W	23	18.0	59	2,485	0.454	0.058	0.109	0.621
6/71	48°08′N 126°13′W	21	12.7	57	2,658	0.349	0.061	0.129	0.539
3/71	S. of Willapa Harbor, Wash.	10	19.0	67	3,086	0.582	0.093	0.159	0.834
3/71	Unknown, Wash.	30	17.7	58	2,535	0.209	0.036	0.089	0.334
10/71	S.W. of Columbia River, Oreg.	60	13.5	40	1,881	0.723	0.068	0.146	0.937
5/71	46°01′N 124°44′W	22	11.6	37	1,522	0.362	0.049	0.078	0.489
5/71	46°00′N 124°48′W	8	12.5	44	2,311	0.336	0.043	0.086	0.465
4/71	46°00′N 124°45′W	1	9.4	37	1,160	2.63	<0.25	0.29	2.92
6/71	45°54′N 124°51′W	20	7.4	37	1,280	0.462	0.040	0.076	0.578
6/71	45°23′N 124°45′W	[3]10		40	1,695	2.70 (1.52)	0.150	0.269	3.11 (1.66)
6/71	45°23′N 124°30′W	29		40	1,867	0.471	0.045	0.100	0.616
10/71	Eureka, Calif.	34	12.9	56	2,335	1.50	0.13	0.23	1.86
10/71	Eureka, Calif.	2	1.6	32	1,270	0.03	n.d.	n.d.	0.03
12/71	Eureka, Calif.	30	6.2	32	849	0.211	0.020	0.026	0.257
12/71	Fort Bragg, Calif.	24	9.8	34	946	0.505	0.051	0.082	0.638
10/71	Santa Cruz, Calif.	19	15.2	40	1,756	3.08	0.39	0.61	4.08
10/71	Santa Cruz, Calif.	11	16.0	50	4,001	7.25	0.57	1.04	8.86
2/72	Pt. Sal, Calif.	10		27	455	0.194	n.d.	n.d.	0.194
5/70	Santa Monica Bay, Calif.	10	6.0	48	831	19.0	2.36	2.05	23.4
11/71	32°26′N 117°33′W	[3]12	14.2	38	1,366	5.77 (1.30)	0.45	1.28	7.50 (1.64)
11/71	32°26′N 117°33′W	25	13.6	38	1,352	7.13	0.56	1.64	9.33
12/71	32°26′N 117°31′W	30	14.3	39	1,406	5.70	0.54	1.33	7.57
4/71	32°25′N 117°22′W	34	10.7	38	1,517	4.79	0.30	0.90	5.99

Note: n.d. = not detected.
SEM = Standard error of the mean (relevant to specimens analyzed individually only).
[1]Fillets analyzed as a composite.
[2]Measured eviscerated and with head off.
[3]Analyzed individually.

Table 6.—Proportions of ΣDDT present as *p,p′*-DDE, *p,p′*-TDE, and *p,p′*-DDT and ratio of polychlorinated biphenyls to ΣDDT in finfishes by state, northeastern Pacific Ocean.

State	All species except sablefish: % of ΣDDT present as DDE	TDE	DDT	PCB (ppm) ΣDDT (ppm)	Sablefish: % of ΣDDT present as DDE	TDE	DDT
Alaska	n.c.	n.c.	n.c.	n.c.	59.2	9.8	31.2
Washington	59.7	18.2	25.0	7.1	67.8	10.5	22.0
Oregon	66.3	12.0	21.3	1.26	79.3	6.5	14.0
California except Los Angeles	80.1	10.5	9.4	0.54	78.8	7.1	14.0
Los Angeles	85.7	7.4	7.6	—	81.2	10.1	8.8

Note: n.c. = not calculable because chlorinated hydrocarbon values below quantifiable level; — = no data because PCB not analyzed.

its metabolites to ΣDDT. In the State of Washington for all species except sablefish, 59.7 percent of the ΣDDT was DDE. Nearly the same proportion of DDE (59.2 percent) was found in sablefish from Alaskan waters. The proportion of DDE increased going southward in all species with a more rapid increase in sablefish. The maximum proportion in that species, 81.2 percent, was nearly achieved as far north as Oregon, 79.3 percent (Table 6). In other species, the increase was more gradual and reached a higher level in Los Angeles, 85.7 percent, perhaps because those species lived closer to the Los Angeles County sewer outfalls. This geographic gradient masked any possible decline with time, which might have been expected, especially in southern California, after DDT dumping ceased in 1970. Similarly, no temporal trend for PCB in Elliott Bay developed in the years following restriction of PCB usage in 1971 (Pavlou and Dexter, 1979).

The reason for the distinctive pattern of ΣDDT accumulation in sablefish is not known. Although a few individuals of this species migrate vast distances, most sablefish remain within a rather limited area after migrating to deep water at the end of their juvenile stages of development[6]. The elevated ΣDDT levels may be associated with the early life in contaminated bays and inlets, the higher lipid content of this species, or both. Alternatively, the deep layers of the ocean may be more polluted than the surface. Chlorinated hydrocarbons, nearly insoluble in water and highly soluble in lipids, partition readily into organic-rich particulate matter and fatty tissues of living organisms. Air and waterborne residues of chlorinated hydrocarbons concentrate in organic material on or in the water column. How demersal sablefish, living in deep water, accumulate higher concentrations of chlorinated hydrocarbons than other fatty species, such as herring, salmon, and saury, which live higher up in the water column, is not yet understood.

Liver, Eggs, Meal, and Oil. The presence of chlorinated hydrocarbons in the edible tissue of fishes and shellfishes raised a question about the levels in other tissues and in fishery products. Chlorinated hydrocarbons are hydrophobic and lipophilic. It seemed possible that they might accumulate to a greater extent in liver, eggs, and other nonedible portions of fishes than in the edible portion. Also the levels in fishery products of this region were unknown.

Early on we examined 16 samples of fish liver in an effort to discover any relationship between the level of ΣDDT in the flesh and in the liver. No clear pattern developed. In three samples of saltwater, hatchery-reared salmon, the liver-to-flesh ΣDDT ratio

[6]Low, L. L., G. K. Tanonaka, and H. H. Shippen. 1976. Sablefish of the northeastern Pacific Ocean and Bering Sea. Processed rep., 115 p. Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, Seattle, WA 98112.

was always below 1. Salmonids may be unique in containing less chlorinated hydrocarbon in the liver than in the flesh. Lieb et al. (1974) emphasized the same unusual finding in a PCB feeding study with rainbow trout, *Salmo gairdneri*. For wild fishes, the values ranged from 1.3 to 106. In general terms, fishes from California had lower liver-to-flesh ratios than those from Oregon and Washington. Hatchery-reared fishes had the lowest values of all, even though the tissue ΣDDT levels were distinctly lower in the hatchery-reared fishes than in wild fishes from California (Table 7).

Two samples of fish eggs were also analyzed. Coho salmon eggs from Skykomish, Wash., in 1970 contained 0.068 ppm ΣDDT and those from Auburn, Wash., in 1975, 0.018 ppm ΣDDT and 0.15 ppm PCB. The difference in ΣDDT level may reflect the decrease in ΣDDT in the environment after DDT usage in the United States was banned in 1973. Alternatively, the difference may be insignificant because ΣDDT was not separated from PCB in the earlier sample. Of interest to both biologist and consumer is the low level of PCB in the eggs and flesh of salmon from Auburn, Wash. These animals traveled through the highly polluted Duwamish River (see above) without accumulating high levels of PCB.

Since fish meal and fish oil, the industrial products of fish reduction, compose significant components of poultry rations, the concentrations of ΣDDT and PCB in these products are important factors in utilization of marine resources. Few data have been published related to fisheries in the northeastern Pacific Ocean. Thus, the limited analyses reported here provide a brief description of an aspect of fisheries seldom reported in the literature. A sample of herring meal from Puget Sound contained 0.049 ppm ΣDDT; the associated oil contained 0.577 ppm ΣDDT. These values can be compared with 0.097 ppm ΣDDT in whole herring caught nearby in Bellingham, Wash. (Table 4). The chlorinated hydrocarbon content of fish meal and oil is related to the amount of oil in each component. Thus, fish meal, which is mainly protein, contains a relatively low level of chlorinated hydrocarbons. In fact, as shown previously (Stout, 1978), when the protein fraction of fish was converted to fish protein concentrate, which is essentially free of oil, the chlorinated hydrocarbons partitioned with the oil. The fish protein concentrate contained less than 0.01 ppm ΣDDT. At a first glance, the level of chlorinated hydrocarbons in herring oil from Puget Sound seemed high (0.577 ppm ΣDDT). Fish oil, however, contains the chlorinated hydrocarbons undiluted by protein or water, so it is logical that the oil contained higher levels of these substances than either the fish from which it originated or the meal produced from the same lot of fish. The levels of chlorinated hydrocarbons in oils from salmon and anchovy correspond with the levels found in the flesh of the same species of fishes from similar geographical areas. Salmon oil from Alaska and Washington contained less than 0.2 ppm ΣDDT, but anchovy oil from California contained 10 ppm DDE (Table 8). The high level of ΣDDT found in a 1955 sample of sardine oil from southern California, 34 ppm, was consistent with the unusual reservoir of ΣDDT located off the Los Angeles County sewer outfalls.

Table 7.—ΣDDT in livers of fishes from the northeastern Pacific Ocean.

Species	Date of collection[1] (mo/yr)	Liver lipid content (%)	Chlorinated hydrocarbon content (ppm) DDE	TDE	DDT	ΣDDT	Liver-to-flesh ratio Lipid	ΣDDT
Albacore	9/70	19.9	0.046	0.101	0.034	0.182	2.0	3.5
Bocaccio[2]	9/70	26.9	46.8	7.37	5.30	59.4	7.1	7.5
[3]	9/70	25.1	168	10.0	13.2	192	8.4	6.6
Bonito	3/71	11.7	8.44	1.46	1.01	10.9	1.5	1.3
Cod, Pacific	9/70	35.7	0.299	<0.015	0.088	0.388	71	>38.8
Rockfish, starry	9/70	31.8	1,170	51.8	73.5	1,300	15.1	17.0
Rockfish, vermilion[2]	9/70	23.8	257	22.8	15.2	295	6.8	6.3
[3]	9/70	27.3	397	5.5	23.9	426	6.5	6.2
Salmon, chinook[4]	9/70	3.0	0.059	n.d.	0.027	0.086	1.2	0.75
Salmon, coho[4]	7/70	3.9	0.019	0.005	n.d.	0.024	0.5	0.17
[4]	9/70	2.9	0.021	n.d.	n.d.	0.021	1.0	0.21
Scad, bigeye	12/70	2.7	n.d.	n.d.	n.d.	n.d.	3.9	n.d.
Scad, mackerel	12/70	2.6	n.d.	n.d.	n.d.	n.d.	3.7	n.d.
Sole, Dover	7/70	9.3	0.135	[5]	0.025	0.160	18.6	>16
Sole, rex	7/70	8.3	0.106	[5]	0.020	0.126	16.6	>12.6
Sole, sand	7/70	18.4	0.517	0.102	0.232	0.851	36.8	106

Note: n.d. = not detected.
[1]All livers analyzed as composites. Location, number of fish, and size data in Tables 4 and 13.
[2]Smaller fish.
[3]Larger fish.
[4]Hatchery reared.
[5]Interference.

Table 8.—ΣDDT and polychlorinated biphenyls in eggs, meal, and oil of fishes from the northeastern Pacific Ocean.

Species	Date of collection (mo/yr)	Location	Type of sample[1]	Lipid content (%)	Chlorinated hydrocarbon content (ppm) DDE	TDE	DDT	ΣDDT	PCB[2]
Anchovy, northern	6/69	California	Oil		10.1	n.a.	n.a.		n.a.
Herring, Pacific	11/68	Puget Sound, Wash.	Meal		0.025	n.d.	0.024	0.049	n.a.
	11/68	Puget Sound, Wash.	Oil		0.283	[3]	0.294	0.577	n.a.
Salmon, coho	11/70	Skykomish, Wash.[4]	Eggs	9.0	0.052	n.d.	0.016	0.068	n.a.
	11/75	Auburn, Wash.[4]	Eggs	6.2	0.016	n.d.	0.002	0.018	0.15
Salmon, sockeye	3/71	Alaska	Oil		0.091	0.064	<0.04	0.155	n.a.
	3/71	Puget Sound, Wash.	Oil		0.070	0.045	<0.03	0.115	n.a.
Salmon, unknown	11/68	Washington	Oil		0.146	<0.08	<0.10	0.146	n.a.
Sardine, Pacific	12/55	Terminal Isl., Calif.	Oil		17.5	9.03	7.44	34.0	n.a.

Note: n.a. = not analyzed; n.d. = not detected.
[1]One composite sample each.
[2]Aroclor 1254 used as standard.
[3]Interference.
[4]Sea-run fish returning to the hatchery.

Statistical Analyses

The 18 samples of 5 or more fish

analyzed individually (Table 3) provided a pool of data for studying the relationships between physical measurements and chlorinated hydrocarbon content. Because of the variability in data discussed previously, a nonparametric statistical test, Kendall's τ, was considered most appropriate. In lingcod from Oregon, correlations were found between length, weight, or age and DDE ($P = 0.05$). For striped bass from Oregon, there were correlations ($P = 0.05$) for length, weight, or age and TDE or DDT, for weight and ΣDDT, and for length or weight and PCB. In albacore from northern California, there was a relationship between length, weight, or lipid and DDE ($P = 0.05$). In bocaccio from southern California length, weight, age, or lipid correlated ($P = 0.05$) with DDE, DDT, or ΣDDT and length, weight, or lipid with PCB. In a set of 25 jack mackerel from southern California, there was a relationship between weight or lipid and DDE, TDE, DDT, or ΣDDT ($P = 0.05$). Length, age, and PCB measurements were not obtained. Kendall's τ was rarely significant for these parameters in the other sets of fish analyzed individually (Tables 9-12). Because of the large variability among individual fish, it was not surprising that correlations between physical measurements and chlorinated hydrocarbon content existed in so few cases, even though such relationships do exist in freshwater fishes (Bache et al., 1972).

Nonetheless, relationships did exist between the chlorinated hydrocarbons present in marine fish. DDT and its metabolites remained in the marine environment to the same extent without preferential loss of DDT, DDE, or TDE. In all 11 samples where TDE and DDT were quantifiable, Kendall's τ for DDE vs. ΣDDT was significant at the 0.05 level (Table 9). Furthermore, ΣDDT and PCB accumulation were also related (Table 12). Both DDE vs. PCB and ΣDDT vs. PCB were significant at the 0.05 level in five of the seven cases in which ΣDDT and PCB were quantifiable.

The frequent correlation between chlorinated hydrocarbons in marine fishes suggested that dispersion of DDT and PCB was linked in some way. PCB was, in fact, proposed as a carrier for DDT to decrease its volatility and thereby increase its persistence. Even so, there is no record that the insecticide DDT and the solvent and electrical insulator PCB were ever intentionally used in combination. Just how agricultural and domestic applications of DDT could balance with dissipation of PCB from electrical equipment and coatings to produce related concentrations of these substances in the marine environment is not clear. Only the ill-defined variable "population density" links these two chlorinated hydrocarbons, i.e., the more people the more insecticides and the more industrial chemicals used and released into the environment.

Table 9.—Kendall's τ between DDE and length, weight, age, lipid, or ΣDDT in fishes from the northeastern Pacific Ocean.

Species	Location[1]	DDE (ppm) vs. fork length	DDE (ppm) vs. weight	DDE (ppm) vs. age	DDE (ppm) vs. lipid	DDE (ppm) vs. ΣDDT (ppm)
Albacore	Northern California	0.511*	0.578*	n.	0.533*	n.
	33°N 135°W	−0.089	−0.178	n.	0.489	n.
Bass, striped	Oregon	0.378	0.422	0.400	0.422	0.911*
	California	0.400	0.178	n.	−0.200	0.956*
Bocaccio	44°N 124°W	0.200	0.111	0.089	0.689*	0.933*
	34°N 119°W	0.711*	0.689*	0.600*	0.689*	1.000*
Bonito	California	−0.222	0.200	n.	0.200	0.867*
Halibut, Pacific	Alaska	0.044	0.044	0.200	0.022	n.
	British Columbia	0.378	0.378	0.489	0.422	n.
	Washington	0.444	0.444	0.356	0.133	0.956*
Lingcod	41°N 124°W	0.622*	0.556*	0.533*	0.156	n.
	35°N 121°W	0.378	0.444	[2]0.306	0.200	1.000*
Mackerel, jack[3]	Los Angeles Harbor	−0.044	−0.2	n.	0.378	0.911*
	Southern California	n.	0.600*	n.	0.507*	0.860*
	Cortes Bank	0.111	0.267	n.	0.444	n.
Sablefish	45°N 124°W	[4]0.089	[4]0.111	n.	n.	0.911*
[5]	32°N 117°W	[4]0.167	[4]0.273	0.333	0.076	0.970*
Salmon, coho[6]	California	0.100	0.200	n.	0.800	n.

Note: Ten fish per sample; * = Kendall's τ significant at the 0.05 level; n. = no data, at least one parameter either unavailable or not quantifiable.
[1] See Table 4 for details except for sablefish, which are listed in Table 5.
[2] One fish omitted, because age not obtained.
[3] Twenty-five fish.
[4] Measured eviscerated and with head off.
[5] Twelve fish.
[6] Five fish.

Table 10.—Kendall's τ between TDE or DDT and length, weight, age, or lipid in fishes from the northeastern Pacific Ocean.

Species	Location[1]	TDE (ppm) vs. fork length	TDE (ppm) vs. weight	TDE (ppm) vs. age	TDE (ppm) vs. lipid	DDT (ppm) vs. length	DDT (ppm) vs. weight	DDT (ppm) vs. age	DDT (ppm) vs. lipid
Bass, striped	Oregon	0.533*	0.667*	0.511*	0.311	0.578*	0.533*	0.600*	0.444
	California	0.089	0.044	n.	0.022	0.333	0.111	n.	−0.044
Bocaccio	44°N 124°W	0.133	0.089	0.200	0.444	0.067	0.067	0.200	0.555*
	34°N 119°W	0.378	0.356	0.378	0.422	0.600*	0.578*	0.556*	0.600*
Bonito	Calif.	−0.178	−0.022	n.	0.511*	−0.244	−0.044	n.	0.444
Lingcod	35°N 121°W	0.356	0.422	[2]0.167	0.311	0.489	0.511*	[2]0.361	0.178
Mackerel, jack[3]	Los Angeles Harbor	0.044	−0.111	n.	0.467	0.200	−0.044	n.	−0.089
	S. Calif.	n.	0.607*	n.	0.480*	n.	0.680*	n.	0.473*
Sablefish	45°N 124°W	[4]0.200	[4]0.222	n.	n.	0.089	0.022	n.	n.
[5]	32°N 117°W	[4]0.348	[4]0.333	0.333	−0.167	0.439	0.364	0.424	−0.258

Note: Ten fish per sample; * = Kendall's τ significant at the 0.05 level; n. = no data, at least one parameter either unavailable or not quantifiable.
[1] See Table 4 for details except for sablefish, which are listed in Table 5.
[2] One fish omitted, because age not obtained.
[3] Twenty-five fish.
[4] Measured eviscerated and with head off.
[5] Twelve fish.

Hawaii

Eight species of fishes from the northeastern Pacific Ocean within 150

Table 11.—Kendall's τ between ΣDDT and length, weight, age, or lipid in fishes from the northeastern Pacific Ocean.

Species	Location[1]	ΣDDT (ppm) vs. fork length	ΣDDT (ppm) vs. weight	ΣDDT (ppm) vs. age	ΣDDT (ppm) vs. lipid
Bass, striped	Oregon	0.467	0.511*	0.444	0.333
	California	0.356	0.133	n.	−0.156
Bocaccio	44°N 124°W	0.133	0.044	0.156	0.622*
	34°N 119°W	0.711*	0.689*	0.600*	0.689*
Bonito	California	−0.267	0.156	n.	0.333
Lingcod	35°N 121°W	0.378	0.444	[2]0.306	0.200
Mackerel, jack[3]	Los Angeles Harbor	0.044	−0.111	n.	0.378
	Southern California	n.	0.660*	n.	0.487*
Sablefish[5]	45°N 124°W	[4]0.088	[4]0.022	n.	n.
	32°N 117°W	[4]0.197	[4]0.242	0.303	0.045

Note: Ten fish per sample; * = Kendall's τ significant at the 0.05 level; n. = no data, at least one parameter either unavailable or not quantifiable.
[1]See Table 4 for details except for sablefish, which are listed in Table 5.
[2]One fish omitted, because age not obtained.
[3]Twenty-five fish.
[4]Measured eviscerated and with head off.
[5]Twelve fish.

Table 12.—Kendall's τ between PCB and length, weight, age, lipid, DDE, or ΣDDT in fishes from the northeastern Pacific Ocean.

Species	Location[1]	PCB (ppm) vs. fork length	PCB (ppm) vs. weight	PCB (ppm) vs. age	PCB (ppm) vs. lipid	PCB (ppm) vs. DDE (ppm)	PCB (ppm) vs. ΣDDT (ppm)
Bass, striped	Oregon	0.511*	0.556*	0.489	0.556*	0.867*	0.778*
	California	−0.044	−0.222	n.	0.200	0.422	0.467
Bocaccio	44°N 124°W	0.089	0.	0.156	0.622*	0.800*	0.822*
	34°N 119°W	0.644*	0.622*	0.489	0.689*	0.889*	0.889*
Halibut, Pacific	Alaska	0.022	0.022	0.222	0.222	0.356	n.
	Washington	0.400	0.400	0.133	0.444	0.644*	0.622*
Lingcod	35°N 121°W	−0.067	0	[2]0.028	0.644*	0.378	0.378
Mackerel, jack	Los Angeles Harbor	−0.022	−0.089	n.	0.356	0.800*	0.711*

Note: Ten fish per sample; * = Kendall's τ significant at the 0.05 level; n. = no data, at least one parameter either unavailable or not quantifiable.
[1]See Table 4 for details except for sablefish, which are listed in Table 5.
[2]One fish omitted, because age not obtained.

Table 13.—ΣDDT and polychlorinated biphenyls in Hawaiian marine fishes.

Species	Date of collection (mo/yr)	Location	No. of animals[1]	Lipid content (%)	Mean fork length (cm)	Mean weight (g)	Chlorinated hydrocarbon content (ppm) DDE	TDE	DDT	ΣDDT	PCB[2]
Goatfish	12/70	Koko Head	[3]12	7.9	23.9	283	0.107	0.089	0.089	0.285	[4]2.24
Marlin, blue	7/72	18°28′N 156°35′W	10		249	101,287	0.008	n.d.	0.006	0.014	<0.05
Moano	12/70	Mokuleia	[3]16	2.3	16.8	106	n.d.	n.d.	n.d.	n.d.	n.a.
Scad, bigeye	12/70	Pokai Bay	[3]14	0.8	20.6	129	n.d.	n.d.	n.d.	n.d.	n.a.
Scad, mackerel	12/70	Barbers Pt.	[3]14	0.7	24.7	169	n.d.	n.d.	n.d.	n.d.	n.a.
Tuna, bigeye	6/72	16°44′N 158°25′W	10	1.0	133	50,500	0.018	0.015	n.d.	0.033	<0.08
Tuna, yellowfin	6/72	20°34′N 158°18′W	10	2.6	148	68,080	n.d.	n.d.	n.d.	n.d.	1.02
Wahoo	6/72	21°05′N 159°08′W	10			16,420	n.d.	n.d.	n.d.	n.d.	0.48

Note: n.d. = not detected; n.a. = not analyzed.
[1]Fillets analyzed as a composite.
[2]Aroclor 1254 used as standard.
[3]Fillets with skin.
[4]Aroclor 1260.

km of the Hawaiian Islands were analyzed. No ΣDDT was detectable in five samples (Table 13). The highest level was associated with onshore pollution. Goatfish, collected on a reef at Koko Head, 16 km from the center of Honolulu, contained 0.285 ppm ΣDDT. Formerly, much DDT was used for insect control in urban areas. The same goatfish also contained 2.24 ppm PCB, which may have come from a nearby harbor; in the past, PCB found widespread use in marine paints and lubricants. How far PCB from this source dispersed is not known, but a composite of 10 yellowfin tuna caught nearly 100 km southwest of Honolulu, contained 1.02 ppm PCB. Since tuna range over vast areas, it was not clear whether this level reflected PCB pollution emanating from the Hawaiian Islands or from distant sites. Wahoo caught about 130 km west of Honolulu contained half as much PCB, 0.48 ppm. In bigeye tuna and blue marlin caught farther south, PCB were below the quantifiable limit.

Conclusions

Chlorinated hydrocarbon levels in the edible tissue of marine animals were generally quite low. A geographical gradient developed going southward from Alaska to southern California. It could be attributed to agriculture, industrial activity, and urbanization. Distinctly elevated levels of ΣDDT and PCB, however, were associated with point sources of contamination, such as the Los Angeles County sewer outfalls and the Duwamish River. Except for sablefish, ΣDDT levels in edible tissue exceeded the Food and Drug Administration guideline of 5 ppm only in fishes taken in the vicinity of the Los Angeles County sewer outfalls, where commercial fishing is restricted to bait fishing. Only in goatfish from Hawaii did the mean level of PCB exceed the proposed Food and Drug Administration guideline of 2 ppm. In no sample did the mean PCB level exceed the current guideline of 5 ppm.

In contrast to what has been found in other research on freshwater fishes, significant positive associations between physical measurements and chlorinated hydrocarbon content existed only in lingcod and striped bass from Oregon, in albacore from northern California, and in bocaccio and one set

of 25 jack mackerel from southern California. Between chlorinated hydrocarbons, however, significant positive associations often existed ($P = 0.05$).

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The Philippines Squid Fishery: A Review

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ABSTRACT—There are several fishing grounds in the Philippines in which squids can be fished all year round. Most squids caught are from coastal and interisland waters. No exploitation is being undertaken in waters adjacent to or beyond the contiguous or economic zone in which lies a potential fishery for oegopsid squids. The major gears used to catch squids are otter trawls for demersal fishing and purse seine, basnig, and scoop nets aided with lights for night pelagic fishing. Also discussed is the present squid fishery using available statistical data, review papers, and current research that deals directly or indirectly with squids.

Introduction

Squids were among the important commercial fishes landed in the Philippines in 1976, representing about 2.08 percent or about 11,000 t (24,250,600 pounds) in the multispecies fishery which prevails. Despite ever increasing squid production, it cannot meet the increasing demand of local, national, and foreign markets.

The amount by which the Philippines can increase its squid production is unknown. Voss (1973) estimated the squid resource for the western central Pacific continental shelf (which includes Hong Kong, Taiwan, Malaysia, Thailand, and the Philippines) at 500,000 t (1,102,300,000 pounds). The Philippines' probable productivity may well be over 25 percent of that estimate. Unknown to us is the possible (and probably larger) stocks of squid in the relatively unexplored outer shelf. This potential stock remains unharvested.

Little has been written about the squid fisheries of the Philippines. Voss (1963) wrote the first extensive report on the taxonomy of Philippine cephalopods. The other important paper is that of Flores (1974) which surveyed traditional Philippine squid fishing grounds. There has been no extensive study on the geographical distribution and abundance of Philippine cephalopods. Likewise, a biological study of a single species of squid has not yet been attempted. Even a review of the Philippines' squid fishery has been lacking. Thus, this report surveys and provides some useful information on the present status of Philippine squid fisheries.

The Squids

Squids harvested in the Philippines belong to the order Teuthoidea, with the suborders Myopsida and Oegopsida. The myopsids, being neritic, are the ones subjected to exploitation, owing to the fishermen's habit of fishing within the interisland and coastal waters of the Philippine archipelago. On the other hand, the oegopsids, being oceanic, are not now being exploited and will not be discussed here.

Four genera and seven species of the Loliginidae have been caught by various fishing gears. Research since 1976 has identified these squids. In the Visayas Sea, Ed Enderez[1] provided the identification with subsequent confirmation from the Department of Zoology, University of the Philippines. In the other research studies, the identification was made by the senior author. In identifying the species, we have relied extensively on Voss (1963).

The local names for *Loligo*, *Sepioteuthis*, and *Doryteuthis* are "pusit" (widely used), "panus" (Southern and Western Tagalogs), "locus" (Visayan), and "bomagto" (Ilocano). *Uroteuthis bartschi* fished in the Palawan waters is commonly named by fishermen as "sputnik" because its body shape is likened to a slim rocket ship[2].

Squid Production

Landings of "squid" have been recorded since the start of the Philippine Fisheries Statistics in 1940 by the Philippine Bureau of Fisheries. Here, the term "squid" will be used to connote either squid, cuttlefish, and octopus unless otherwise specified. Similar records have been kept also by the Food and Agriculture Organization of the United Nations.

Table 1 shows the squid production trend for 1957-76. The total commercial catch can be characterized by a gradual increase with a few declines spaced between several successive years. This upward climb may be due to the increase in the use of otter trawls, purse seines, and beach seines. While the bagnet occupies an important role in the fishing industry, and is a very productive gear at that, the number has been fluctuating. This may indicate additional production with an increased number of gears or lower production with less bagnets (Tables 2, 3).

Municipal (also called sustenance or artisanal) fisheries, an important factor in the Philippines' national fish production, lacked detailed figures on its squid catch until 1976. The municipal sector then contributed as much as 50 percent, in which squid, cut-

[1] Ed Enderez, Fisheries Division, Development Bank of the Philippines, Makati, Philippines. Personal commun.

[2] Antero Belnas, Bureau of Fisheries and Aquatic Resources, Intramuros, Manila. Personal commun.

Table 1.—Total commercial squid catch in metric tons for the Philippines, 1957-76. Source: BFAR, 1957-76.

Year	Quantity (t)	Year	Quantity (t)
1957	154	1967	4,782
1958	203	1968	9,222
1959	356	1969	6,366
1960	281	1970	5,862
1961	254	1971	5,714
1962	1,363	1972	7,451
1963	2,913	1973	7,174
1964	3,629	1974	9,265
1965	4,964	1975	13,704
1966	5,604	1976	10,560

Table 2.—Numbers of commercial fishing gear in the Philippines. Source: BFAR (1957-76).

Year	Bagnet	Beach seine	Purse seine	Otter trawl	Round haul seine
1967	1,002	45	197	593	108
1968	883	44	202	653	85
1969	796	41	253	667	69
1970	858	49	245	653	76
1971	743	35	265	652	61
1972	650	44	320	690	53
1973	791	41	470	794	50
1974	584	51	280	767	38
1975	713	77	313	763	27
1976	656	75	342	786	20

Table 3.—Catch percentage by type of fishing gear on squid. Source: BFAR (1957-76).

Year	Total catch (kg)	Bagnet	Otter trawl	Beach seine	Purse seine	Round haul seine
1971	5,713,480	6.16	92.73	0.24	0.80	0.08
1972	7,439,370	33.34	62.81	—	2.51	1.35
1973	7,174,460	25.49	63.12	—	10.81	0.58
1974	9,264,660	8.93	84.14	—	6.82	0.10
1975	13,603,090	13.11	82.94	0.03	3.88	0.03
1976	10,553,560	11.59	77.39	—	10.31	0.71

Table 4.—Major Philippine squid fishing grounds based on production (in metric tons). Source: BFAR (1957-76).

Year	Asid Gulf	Bohol Sea	Guimaras Strait	Lamon Bay	Manila Bay	Ragay Gulf	Samar Sea	San Miguel Bay	Sulu Sea (N)	Tay-abas Sea	Visayas Sea
1971	8.1	85.0	115.7	645.5	480.2	363.5	203.9	185.0	1,144.8	134.1	2,733.3
1972	0.4	101.6	99.2	1,309.8	532.6	467.9	975.2	975.2	321.8	—	3,168.6
1973	50.5	96.3	298.1	167.3	594.1	26.6	117.2	1,039.2	109.0	155.3	2,977.4
1974	389.9	1,302.8	128.4	594.0	433.8	56.6	117.8	333.5	79.6	124.8	5,769.7
1975	835.2	16.2	356.4	961.7	1,202.4	9.5	276.6	246.3	158.8	219.8	7,161.1
1976	782.0	42.2	302.8	—	531.7	8.5	833.6	229.0	0.05	113.7	6,621.9
$\bar{x}$	344.4	274.0	216.8	613.1	629.1	125.4	334.7	451.4	302.3	124.2	4,738.7

tlefish, and octopus, grouped separately, were estimated at 13,079 t (28,833,963 pounds) compared with 10,560 t (23,280,576 pounds) from the commercial fishermen.

There are about 47 known fishing grounds in the Philippines, of which 6 areas lack catch records (BFAR, 1957-76). Table 4 shows production of the important fishing areas for squids. Several areas not shown have at one time produced more than 100 t (220,460 pounds) of squid per annum (BFAR, 1957-76). However, on the average, their production is quite low compared with the top 11 fishing grounds (Table 4).

The squid catch of the 11 major fishing areas follows a generally variable or downward trend. Only the Samar Sea and the Bohol Sea have shown an increase in the squid catches. To assess whether a fishing ground is underexploited, fully exploited, or overfished, an evaluation of the catch per unit effort under a number of years must be analyzed (Simpson, quoted by SCSP, 1976). Four independent variables are needed, which can be used separately, and consist of the numbers of: 1) Vessels operating on the fishery, 2) days fished, 3) trips, and 4) hours fished. On the last three requirements, Yamamoto (1973) stated that there is very little data that can be gathered from the Bureau of Fisheries' "Monthly Fish Caught Report."

The following paragraphs were based on a series of BFAR/SCSP[3] Workshops (SCSP, 1976-79) which gave a general review on the status of resources and the potential yield of squid by fishing grounds.

The first workshop covered the fishing areas between Luzon and Mindanao Islands, the Sibuyan and the Visayas Seas (Fig. 1). It is the most heavily fished area in the Philippines, producing over 50 percent of the total catch by municipal and commercial fisheries for the whole country. Included in these areas are the Tayabas Bay, Samar Sea, Ragay Gulf, Asid Gulf, Guimaras Strait, and other fishing grounds.

This first workshop made use of the catch per trawler to obtain the estimated total fishing effort. Squid as well as cuttlefish were treated as one. Between 1965 and 1974, statistics showed increasing effort but with the total catch increasing very little (Fig. 2). It was surmised that the area is fully exploited and the maximum yield is expected to be around 1,200 t. The Visayan Sea and Guimaras Strait contributed much to the production of squid while the rest produced a minor quantity. It seems that the Samar Sea has been overlooked. Trawl and basnig (bagnet) are the main gears but jigging by municipal vessels does occur (Table 5).

The second workshop did not mention squid in particular but the areas analyzed, including the Sulu Sea, Bohol Sea, and Moro Gulf, are rich grounds for pelagic fishes.

The third workshop dealt with the coastal Pacific side of the Philippines. This area, comprising five regions, has a rugged coastline and an extensive continental shelf extending over 1,500 km (900 nautical miles). San Miguel Bay, the most productive fishing ground in the Philippines per unit area, is located here. The northern or upper region (Region II) was excluded in this discussion. Four regions (IV-A, V, X, XI) produced 90 percent squid among the cephalopod groups. Basnig was the most productive in the commercial and municipal sector and, on the other hand, the scoop net with light and ringnet are the second and third most productive fishing gears (Table 5).

[3]Bureau of Fisheries and Aquatic Resources and South China Sea Programme.

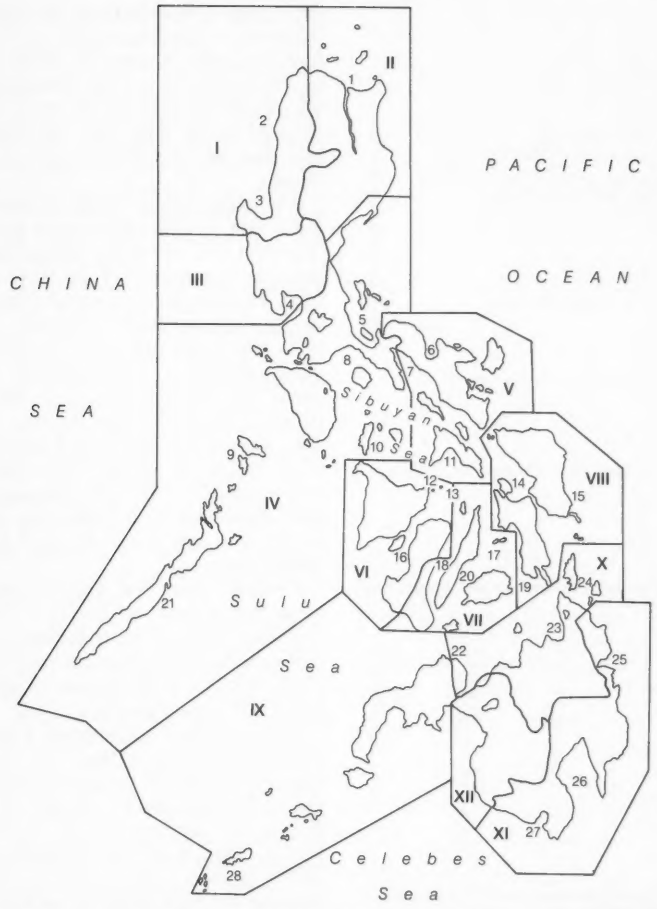

Figure 1.—The Philippines showing Fishery Regions I-XII and squid fishing grounds: 1=Babuyan Channel; 2=Ilocos Region; 3=Lingayen Gulf; 4=Manila Bay; 5=Lamon Bay; 6=San Miguel Bay; 7=Ragay Gulf; 8=Tayabas Bay; 9=NW Busuanga; 10=South Sibuyan Sea; 11=Asid Gulf; 12 and 13=Visayas Sea and western part; 14=Samar Sea and adjacent Carigara Bay; 15=Matarinao Bay; 16=Guimaras Strait; 17=Camotes Sea; 18=Tañon Strait; 19=Cañigao Channel; 20=Bohol Strait; 21=Village Bay; 22=Murrielagos Bay; 23=Butuan Bay; 24=Dinagat Sound; 25=Lianga Bay; 26=Davao Gulf; 27=Sarangani Bay; and 28=Manok Mankaw.

The fisheries in these areas are governed by the northeast monsoon which greatly reduces the number of fishing days between December and March. Consequently the amount of fishing possible could vary considerably from year to year (SCSP, 1978). One cannot, therefore, depend much on the number of boats as an index of fishing effort. The last three variables previously mentioned are advocated as a better substitute. However, these data are not available, and therefore any satisfactory estimate of the resource and potential annual yield cannot be undertaken at this time. Speculation about the stocks of pelagic species off the Pacific coast have been mentioned.

The northern and western coast of Luzon were the last areas assessed. Similar problems like those of the previous workshop were encountered. Data for analysis on potential yield and status of stocks are incomplete in the previous years. There is a strong belief that a large quantity of squid abounds off the western Philippine coast. Again squid are caught by trawls, and at night by lift nets with lights to attract these myopsids. Harvesting is by hook and line, including jigs.

In almost all the workshops, we see that the squid, including cuttlefish and even the octopus, were given recognition as an important stock contributing to major production.

Fishing Methods

Though the present squid fishery is limited to sustenance fishermen (Flores, 1974), many loliginids are taken from otter trawls, basnig, purse seine, round haul seine, and scoop nets. Statistical data on myopsid squid at the municipal level are available only after 1975. Table 3 shows squid catches by five commercial fishing gears.

In Figure 3, the most common squid jigs used by sustenance fishermen are shown. Operation of the shrimp-type jig and the cylindrical-type jig are limited to one line, so fishermen, to increase their catch, should set at least three or four lines while fishing. The Tañon Strait jigs are used in waters 200 m (656 feet) deep while the cylindrical type with the whole fish bait is a bit similar to the second type. The difference is that the hooks have a wider spread. Table 5 shows Region VIII which includes the northern and eastern Samar Sea as the area where squid jigging is most prevalent.

Figure 4 shows the commercial and municipal squid fishing seasons. Generally, the fishing by municipalities is continuous throughout the year with peak seasons occurring at different places.

Rasalan and Datingaling (1953) reported on the fishing gears which use lights. This section will briefly describe the fishing methods and some of the following account on the seines

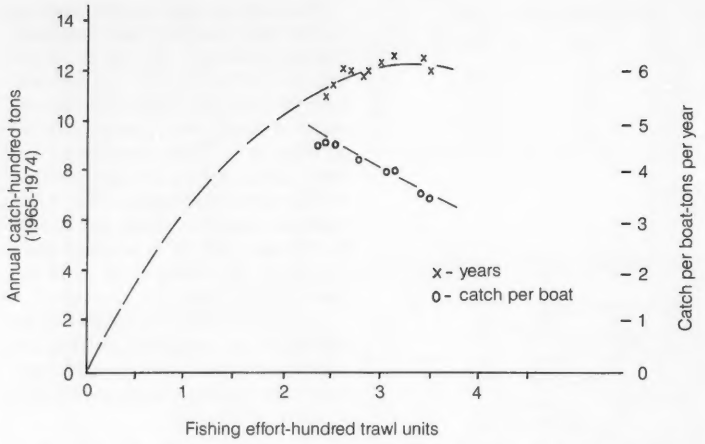
Annual catch-hundred tons (1965-1974)
Catch per boat-tons per year
x - years
o - catch per boat
Fishing effort-hundred trawl units

Figure 2.—Profile of Philippine squid catch per unit effort. Region VI. Source: SCSP (1976).

Table 5.—Philippine squid and cuttlefish catch in 1976 separated according to region and gear (in metric tons)[1]. Source: SCSP (1978).

Gear	Fishery[2]	Region IV-A	V	VIII	X	XI	Total	Percent
Bagnet	C	16	247	—	—	—	263	4
	M	—	22	971	636	—	1,649	28
Ring net	M	4	—	777	—	166	947	16
Beach seine	M	—	—	—	—	886	886	15
	C	12	67	—	—	—	79	1
Trawl	M	—	—	—	—	—	—	—
Spear gun	M	—	380	—	—	55	435	1
Scoop net with light	M	—	1,348	—	—	—	1,348	23
Jigger	M	—	—	194	—	—	194	3
Scoop net	M	—	30	—	—	—	30	1
Not classified	M	81	—	—	—	—	81	1
Totals	C	28	314	0	0	0	342	6
	M	85	1,780	1,942	636	1,107	5,550	94

[1] Workshop on the Fishery Resources of the Pacific Coast did not include Region II.
[2] C = Commercial; M = Municipal.

(except purse seine) are extracted from that paper.

The round haul seine is an indigenous commercial gear locally known as "sapyaw." The sapyaw can be operated during daytime or nighttime. At nighttime it is usually aided by a third boat which also acts as a tow vessel. This boat usually carries a light and leads the attracted school between the two boats where the net awaits the catch. This gear is bulky and requires several hands. Thus, it may become a costly operation as there is less profit when employing a larger crew. More are converting to basnigs which are cheaper to operate than sapyaw. The popularity of the round haul seine (Table 2) is declining.

The least productive of the commercial/municipal methods of fishing is the beach seine. Common to fishing villages, the beach seine is operated once or twice a day or at night, and the work is done by the villagers. During the dark phase of the moon, the boats equipped with lights go out to attract the fish, bringing them nearer to shore and the net. Hauling time to shore usually averages 3 hours or more, depending on the currents and the mode of operation. Catch per season is sometimes insignificant due to the presence of trash fauna, especially ophiuroids and jellyfishes. There are more people involved at one time with this single gear than with any other method now in use.

The purse seine, using artificial lights, was first introduced in the Philippines in 1962 (Ronquillo, 1972). This gear has now surpassed the trawl in total productivity for several years, though there are more than twice as many otter trawls (Table 2). This gear, when operated at night with light to attract fish, catches from 35 to 100 t (from 77,161 to 220,460 pounds) of fish. Rasalan (1968) reported catches of 100 t (220,460 pounds) in the Palawan waters. This gear might well be the most productive squid fishing gear although it is not solely designed for squid fishing.

Probably more has been written about fishing with the basnig in the Philippines than any other fishing gear (Rasalan, 1959; Rasalan and Villadolid, 1955; Spoehr, 1968; Manacop and Laron, 1953; and Ronquillo, 1972).

The basnig is an indigenous gear that originated in northern Panay and adjacent areas. Although this gear ranks as the third most productive fishing gear, it does not contribute to the export market. The catches are immediately landed in local markets because the boats do not have refrigeration facilities. But, in catering to local markets, it helps to alleviate shortages of fish in rural areas. Otherwise, the catches would be mostly distributed in urban and semiurban areas.

The basnig, a totally night fishing gear, is operated near submerged shoals and reefs, using lights to attract fish to the net (Manacop and Laron, 1953). This gear, along with the purse seine and round haul seine employing lights, accounted for about 23 percent of the Philippines' total commercial fish production in 1976.

Basnig boats proceed before twilight to their destination where they set their nets once or twice in the night. The net, which resembles an inverted box-type mosquito net, is hung under the boat

(Fig. 5). Net size can be determined by adjusting the lengths of booms or outriggers. Several lights on the sides of the boats are dimmed when the net is about to be hauled. The ropes attached to the basnig are pulled manually. Due to its unmechanized setting and hauling, large and fast moving fishes can easily escape the net. The boats return before sunrise to avoid spoiling the catch.

The otter trawl is the most important fishing gear that contributes to the squid fishery. The municipal fisheries have small trawlers, less than 3 gross tons, which, collectively, can equal the catch by the commercial fishery. The trawl which was originally conceived to catch demersal fishes of high market value like *Caranx* sp., *Formio* sp., and shrimps, have been catching squid as well. While certain species of fish appear in certain seasons, squids are caught year-round on almost all fishing grounds.

On the average, the trawl contributes 75 percent to the overall squid catch. Because the trawlers are mainly concentrated inside the territorial waters, it is expected that catch will maintain a slow, gradual production increase unless more vessels are recruited. At this stage the shift to oceanic resources is still in the future. The major constraints to this shift in fishing areas are the high capital investment and the risk in unexploited fishing grounds. Mainly, the problem would be locating the new fishing areas. Catch increases in the next 5 years are likely to be slow due to the use of traditional fishing methods.

The estimated landings of the western central Pacific by Voss (1973) was 100,000 t (220,460,000 pounds). The Philippines contributed about 23 percent to this estimation based on the combined municipal and commercial fisheries. This catch however is minimal when compared with potential catches.

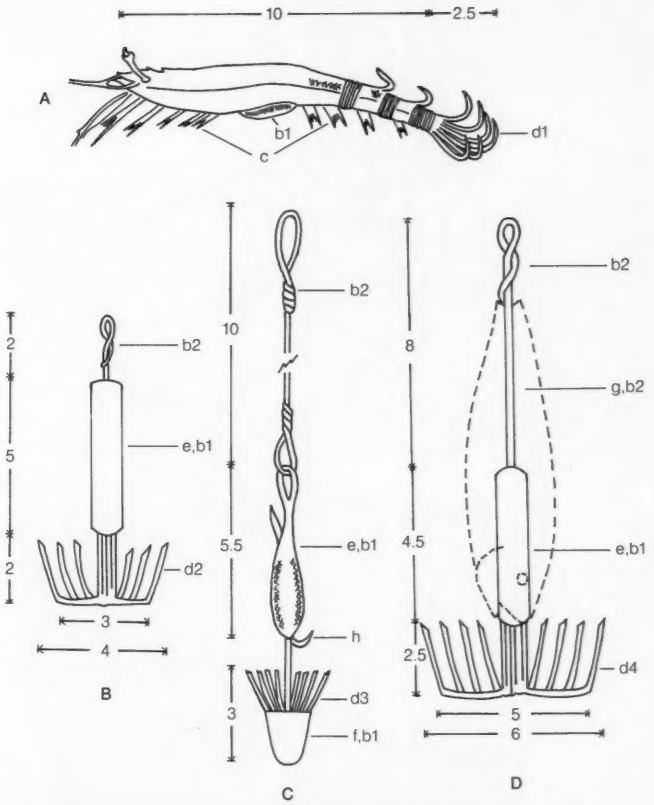

Figure 3.—The most common Philippine squid jigs. A=Shrimp-type jig; B=Cylindrical-type jig; C=Tañon Strait cylindrical jig with bait attachment; D=Cylindrical-type jig with whole fish bait; a=plastic ball "eye"; bl=lead weight; b2=stainless steel; c=nylon monofilament "appendages"; dl=barbless hooks, 12 pcs stainless wire 200-pound test; d2=barbless hooks, 12 pcs stainless steel; d3=barbless hooks, 14 pcs stainless steel; d4=barbless hooks, 16 pcs stainless steel; e=body; f=cone; g=shaft; h=hook for bait attachment. All measurements are in centimeters. Source: Flores (1974).

Research

Some of the research presented here did not include or involve squid research because they were generally stock assessments of demersal fishes. However, trawling gear was used and loliginids were also taken and recorded. This section presents results of studies conducted in the different interisland seas most of which contain useful squid fishery data.

At the height of a growing clamor for closures of certain traditional and productive fishing grounds for management and regulation purposes, several fishing areas in the Philippines were designated for assessment and investigation to determine whether these are potential fishing grounds or whether they are depleted of marine resources. (The Malampaya Sound, located in the northwestern portion of Palawan, was closed in 1973 under Fisheries Administrative Order III.)

Virginia Aprieto, former Director of the Institute of Fisheries Development and Research, initiated early in 1974 sustained studies on the fisheries, biology, and ecology of traditional and nontraditional fishing grounds. So far

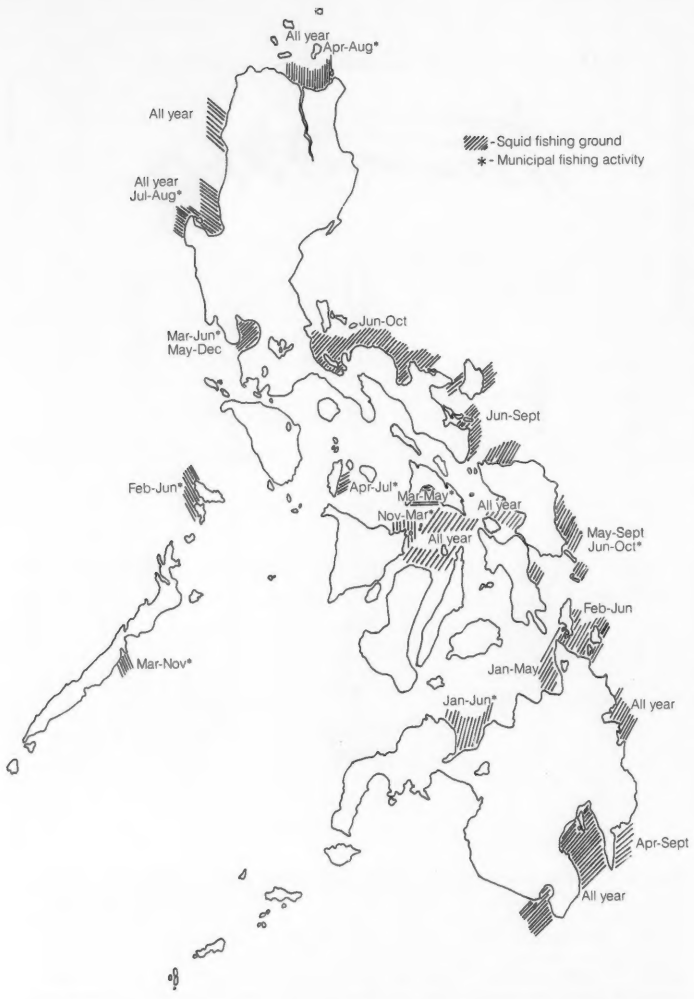

Figure 4.—Areas and main months in which Philippine squids and cuttlefish are caught (modified). Sources: SCSP (1976) and Flores (1974).

four papers have been published and more are being readied. The principal author has participated in some of this investigation and also discusses here a current project. The data or figures presented in this section are not final, until published separately. Summaries of this research follow.

The first in the series deals with echo surveys of northwestern Palawan waters (Aprieto et al., 1974). This area is adjacent to Malampaya Sound. Before the closure was enforced, it ranked in the top 10 fish producing grounds in the Philippines where the majority of the catch was taken from pelagic fisheries. To provide additional trawling areas and to break away from the traditional fishing grounds, new areas were explored. This 125,950 km^2 area representing a nontraditional fishing ground showed echographs of fishes. However, it further revealed steep slopes, peaks, and a rugged bottom. An experimental trawl in the area which is supposedly trawlable got snagged after 30 minutes. The total catch, one *Alectis* sp., three nemipterids, four *Loligo* spp., one *Scoliodon* sp., sponges, and alcyonarians, represented some of the probable stocks.

The senior author was only able to join two cruises in the Visayan Sea Project (conducted from 1976 to 1977). All 12 fishing tracks were positive for squid. The species present, in order of relative abundance, were: *Loligo* sp. (Voss, 1963); *L. duvauceli* and *L. edulis*; *Sepia pharaonis*[4], *Doryteuthis singhalensis*, and *Sepia esculenta*. *Sepioteuthis lessoniana* was caught in small numbers. Generally the Visayan Sea substratum is sandy-muddy as determined by systematic random samples.

Lingayen Gulf was the site of the third fishing ground investigated. Nine out of the twelve stations were set for a 2-hour standard tow. All tracks fished produced loliginid squids averaging 2.4 kg (5.3 pounds) per track. The squids caught were similar to those taken in the Visayan Sea. However, the most abundant was *Loligo duvauceli*, followed by sepiids *Sepia esculenta* and *S. pharaonis*. Occasional catches of *Sepioteuthis lessoniana* and *Loligo edulis* were noted. One *S. lessoniana* caught weighed 1.5 kg (3.3 pounds). In higher latitudes Choe (1961) noted specimens attaining 3.0 kg (6.6 pounds). Several *Octopus membranaceus* and other unidentified octopi were caught, some resembling the unknowns of Voss and Williamson (1972).

The loliginid catch consisted mostly of various sizes ranging from 3.5 to 14 cm (from 1.4 to 5.5 inches) with an average mantle length of 7.5 cm (2.9 inches). Most *Loligo duvauceli* were egg bearing at 5 cm (2 inches). On the basis of field observations the subsampled squid population does not spawn singly in a particular season but has

[4] *Sepia* is not a loliginid.

a protracted spawn year-round. *Doryteuthis singhalansis* were few in the trawling test but were observed to be present in the local market bordering the Lingayen Gulf.

Trawling investigations in the neighboring Samar Sea and Carigara Bay are currently being conducted by the Department of Marine Fisheries, College of Fisheries, University of the Philippines. There were 28 fishing tracks out of the original 34 plotted on the map. A standard 1-hour tow was made in each track per month. Five months of fishing had averaged 198 kg (435.6 pounds) per month. For the Samar Sea alone it was 158 kg (347.6 pounds) per month. There was an abundance of *Sepia pharaonis* and *Loligo duvauceli* with the latter species appearing more often. *Sepia esculenta* and *Sepioteuthis lessoniana* were also present in the fishing area. *Sepioteuthis lessoniana* were large with lengths reaching 30 cm (12 inches) while *Sepia esculenta* ranged from 7 to 10 cm (from 2.8 to 4 inches).

This relative abundance result seems to indicate that the Samar Sea is productive (Table 4). However, due to a Presidential decree banning trawlers within 7 km (4.3 miles) of shore, the fishing effort in the area was reduced. This might account for the large catch.

Developments

From the above discussion, it can be concluded that the Philippine squid fishery has been given little attention. However, there is now a government program on the development of municipal fisheries which may well include squid fishing. For commercial fishing, the government relaxed its policy on the importation of secondhand vessels. This move was hailed by the fishing industry because it believes it can boost annual catch by 32,000 t (70,547,200 pounds) (Anonymous, 1979). These boats, however, will probably not introduce new technology as they will be used to increase the otter trawl and purse seine fleets.

Foreign aid has been contributing its share too. The ongoing Samar Sea/Carigara Bay Project testing the midwater trawl is done in cooperation with the German Technical Aid Program.

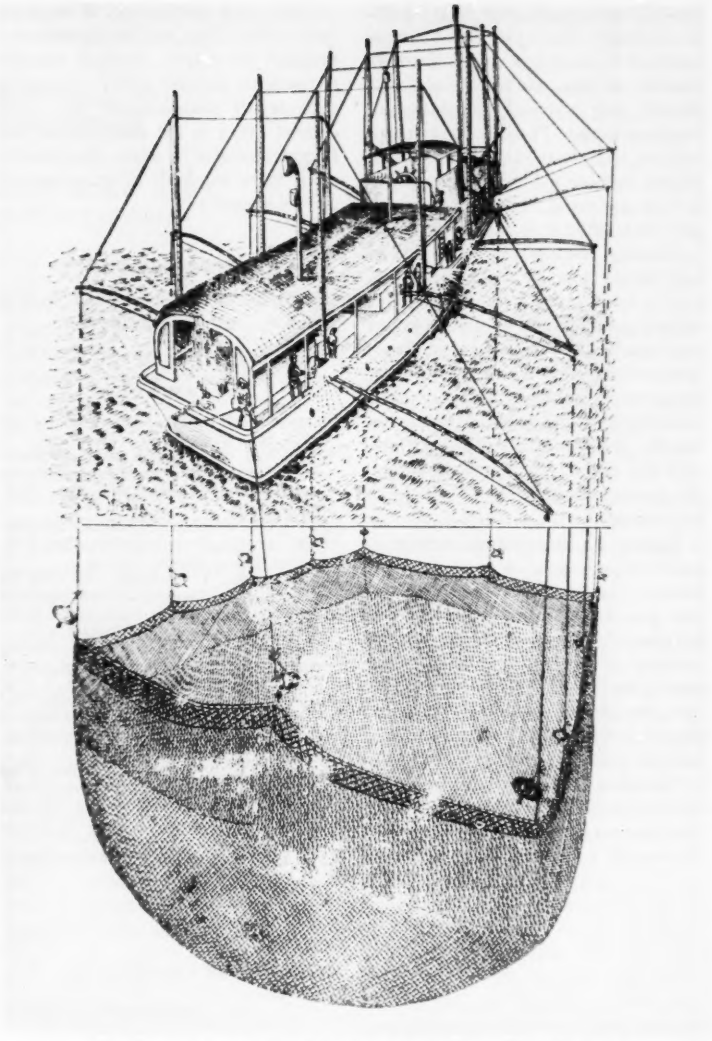

Figure 5.—A motor vessel basnigan in operation. After Manacop and Laron (1953).

No such gear has been used in the Philippines before. According to Peter Jarchau[5] some countries have met success with the midwater trawl and the Japanese have used it to catch squid. In practice, the new trawl can function both as a near-bottom and as a pelagic gear.

Conclusion

The Philippines has one of the most extensive coastlines and territorial waters in which a healthy economy could be built through fishing. Several spe-

[5]German technical adviser. Personal commun.

cies of cephalopods, especially squids, are available for which no potential stock measurement is yet known. Coastal, inshore, and territorial waters abound with myopsid and with some oegopsid squid. The fishing industry, with its numerous vessels, has so far limited itself to fishing in waters close to land and could, in time, overcrowd and overexploit that marine resource.

Trawling remains the most productive fishing gear for squid. However, only a small portion of the possible fishing grounds are available to the otter trawlers. What remains are larger nontrawlable areas where vessels using the purse seine, basnig, and scoop nets aided by lights can venture. By increasing the number of boats using lights with the above gear, we believe that the present production of squid can be doubled.

Jigging is the common method of squid exploitation in the municipal fishery. The number of people using this gear is unknown, but could be substantial in view of Smith's (1979) estimate of 500,000 municipal fishermen in the Philippines. Financial attention should be focused on the squid jiggers as they utilize inexpensive fishing gear and low technology.

Identification and geographical distribution data on squids are lacking so that species stock assessments cannot be properly conducted.

Local and foreign squid markets have grown. Thus, the Philippines must broaden its marine product exports to include canned fishery products because all canned squid and some canned fishes in the local market are import products in which the government loses hundreds of thousands of dollars annually.

Acknowledgment

We especially wish to thank Norman Reyes for the basnig picture.

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Processing Wastewater From Two Mechanized Salmon Canneries

FREDERICK E. STONE, HAROLD J. BARNETT, PATRICK J. HUNTER, GLENN C. ROBERTS, and RICHARD W. NELSON

ABSTRACT—Wastewater discharged from seafood processing plants is subject to the Environmental Protection Agency regulations and guidelines. This study was performed to estimate the amounts and variability of waste loads from salmon canneries. The amount of 5-day biological oxygen demand, total suspended solids, and oil and grease discharged by two mechanized salmon canneries was determined. Variations in the composition of the processing wastewater, daily water use, and production levels are described. Both canneries complied with the EPA recommended effluent limitations more frequently as daily production increased.

Introduction

In 1972, Congress approved the Federal Water Pollution Control Act (PL 92-500) which enabled the Environmental Protection Agency (EPA) to establish guidelines and performance standards for seafood processing wastewater.

A survey was made of the industry and the results reported in a series of development documents (EPA, 1975). After considering the available information, the EPA recommended guidelines limiting the amount of 5-day biological oxygen demand (BOD_5), total suspended solids (TSS), and oil and grease (O&G) in wastewater discharged by mechanized salmon canneries. Performance standards for best practical control technology currently available (BPCTCA) and best available technology economically achievable (BATEA) were promulgated in the Federal Register (EPA, 1976).

This study was initiated in response to industry requests for information concerning treatment systems for fish-processing wastewater. The information published in the development documents (EPA, 1975) suggested that the amount of waste discharged for each unit of production varies daily and is different for each cannery. To select treatment systems which will comply with the EPA guidelines, it was necessary to determine the range, frequency, and causes for the variation in the amount of waste discharged by individual canneries.

Accordingly, intraday and daily variations in the composition of wastewater from two west coast mechanized salmon canneries were measured and compared. Relationships between the amount of processing waste discharged, daily production, water used, and the BOD_5, TSS, and O&G concentrations of the wastewater were determined. The long-term average and daily maximum discharge expected at each level of production were calculated and compared with the EPA recommended guidelines.

Materials and Methods

Cannery Description

Two salmon canneries, designated as A and B, were evaluated during the 1976 fishing season. Both canneries used standard processing equipment, such as mechanical butchering machines, sliming tables, gang knives, and can-filling machines. The processing, canning, retorting, and wash-down procedures were similar to those observed elsewhere in the industry.

In both canneries, heads, tails, and viscera were collected before they entered the wastewater. Cannery A delivered this offal to local farmers who used it as a soil enhancer, while Cannery B used it in pet food production. Cannery B rendered some of the fish heads to recover salmon oil. Both canneries processed salmon roe as a by-product.

As is usual in mechanized salmon canneries, scraps accumulated on the floor in all the processing areas, especially at the butchering and can-filling machines. These wastes entered the wastewater when the plants were washed using high-pressure hoses. In addition, large amounts of waste were discharged at unscheduled intervals due to frequent spills, breakdowns, and the dumping of rendered fish heads and roe-processing brine.

Routine wash-down procedures were thorough at the end of the work day and superficial during lunch time and coffee breaks. Approximately the same amount of time, labor, and volumes of water were used to clean the equipment regardless of the duration or rate of production.

In both canneries, a series of flumes and floor drains, covered by grates having 2.54 cm (1 inch) openings, delivered wastewater from the work areas to an effluent collection sump. When full, the contents of the effluent collection sump were automatically pumped to a headbox located at the entrance to the wastewater treatment system being investigated. Wastewater in the headbox was well mixed and representative of the effluent subject to the EPA guidelines for point sources of discharge.

Sampling Techniques

Intraday grab samples were manually collected from the headbox. A table of random numbers (Youden and Steiner, 1975) was used to select time intervals between samples so that the probability

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of including variations in production, water use, or waste concentration (such as occur during lunch hour, spillage, or wash-down procedures) in each sample would be proportional to the frequency of occurrence.

Daily composite samples were obtained by combining the individual grab samples in proportion to the discharge rate measured at the time the samples were taken (Harris and Keffer, 1974).

Water used at Cannery A was measured by a rotary-style meter in the city water line. The flow rate of the wastewater, when samples were collected, was determined by measuring the time required to fill the 450 liter (119 gallon) effluent collection sump.

Wastewater from Cannery B flowed through a 45.7 cm (18 inch) H-flume before entering the collection sump. The height of the wastewater in the flume was continuously monitored by a Westmar[1] ultrasonic probe. The instantaneous flow rates and daily totals were recorded with a standard error less than ±1 percent. The accuracy of this method was confirmed by emptying a 7,571 liter (2,000 gallon) tank of water through the flume at a known flow rate.

Both canneries were plumbed so that only water used for production and wash-down procedures was included in the daily total. Water used for cooling retorts and other purposes not covered by EPA guidelines was not included in the totals.

Daily production was determined by totaling the weight of totes full of salmon purchased from the boats and processed on a particular day.

The average amount of water used by butchering machines, sliming tables, can fillers, and similar processes for each unit of production was estimated by the slope of the linear regression line which correlates daily water use and production. The amount of water used regardless of the amount of fish processed was estimated by extrapolating the ratio of daily water use and production to zero production.

[1]Reference to trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

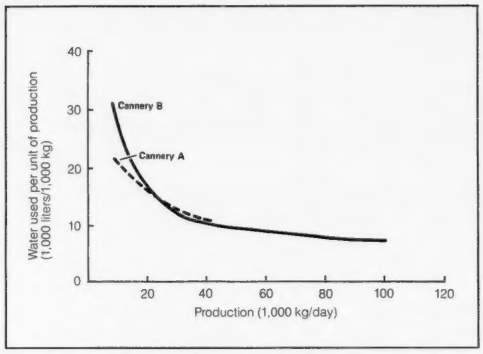

Figure 1.—Water used per unit of production as a function of daily production.

The amount of water used for each unit of production (flow ratio) was determined for each level of production. The flow ratio was multiplied by the analytical results to determine the waste discharged for each unit of production (EPA, 1975) and then by daily production to obtain the total discharge.

Analytical Techniques

All chemical and biological tests were made according to the methods described in the 14th edition of Standard Methods (APHA, 1975) or by the EPA (1974). Statistical quality control was employed when evaluating the data. Results were considered acceptable when duplicate analyses were within the 95 percent confidence intervals established for these tests (APHA, 1975; Youden and Steiner, 1975).

Total suspended solids (TSS) were separated from filterable residues (FR) by filtering aliquots of wastewater through a Gelman type A glass-fiber filter paper (EPA, 1974). The TSS retained by the filter paper was weighed after drying in an oven at 103°-105°C for 1 hour. The FR was determined by evaporating the filtered wastewater to a constant weight at 103°-105°C.

Total residues (TR) were measured by evaporating aliquots of wastewater to constant weights in an oven at 103°-105°C.

Values for total residues and filterable residues were reported after subtracting the sodium chloride (NaCl) content of the wastewater from the analytical results.

Results and Discussion

Water Used for Each Unit of Production (Flow Ratio)

Both canneries used water more efficiently as production increased. The average amount of water used for each unit of production (flow ratio) decreased as daily production increased (Fig. 1). The relative error of the flow ratio was ±11.8 percent at each level of production.

The amount of water used by the butchering machines, sliming tables, can fillers, and similar processes was proportional to the duration and rate of production. The average amount of water required for wash-down procedures and purposes other than production was relatively constant at all levels of daily production at both canneries (Fig. 2).

Analytical Results

The composition of the untreated wastewater from both canneries was very similar (Tables 1, 2). The concentration of waste in the samples from both canneries followed similar distribution curves at all levels of daily water use and production investigated. Although initially highly concentrated, the average composition of the wastewater during wash-down and production periods was similar.

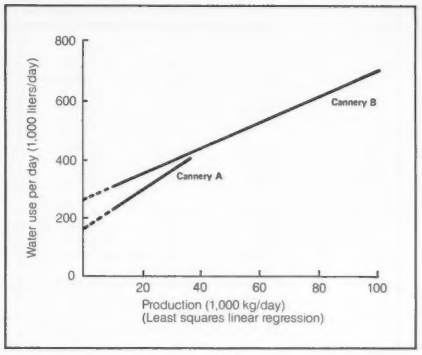

Figure 2.—Water used for each day's production at Canneries A and B. Data points omitted at the request of the canneries.

Table 1.—Intraday random samples—mechanized salmon processing canneries A and B.

Item	Cannery	Day	No.[1] of samples per day	Waste concentration (mg/l) Daily mean	Daily SD	Observed Min.	Observed Max.
TR	A	1	10	3,381	867	1,900	5,000
TR	A	2	30	1,986	645	956	3,146
TR	B	1	9	2,714	1,058	1,330	4,540
TR	B	2	25	3,921	1,114	1,690	5,560
TR	B	3	15	2,056	1,037	858	4,258
TR	B	4	30	3,790	4,024	38	10,066
TSS	A	1	10	1,680	383	1,062	2,067
TSS	A	2	30	959	339	395	1,595
TSS	B	1	10	1,936	566	1,062	2,585
TSS	B	2	9	1,924	979	995	2,590
TSS	B	3	20	2,906	1,375	1,595	6,174
TSS	B	4	28	2,404	807	1,225	3,235
FR	A	1	30	990	424	0	2,490
FR	B	4	22	1,522	615	150	3,380

[1] Results accepted when duplicate analyses were within the 95 percent confidence intervals established for these tests.

The analysis of numerous grab samples revealed rapid fluctuations in the waste loads (Fig. 3). The complexities of a salmon cannery, however, make it difficult to associate these fluctuations with any single event.

Statistical analysis of the data indicates a combined relative error due to sampling and analysis of approximately ±8.7 percent for BOD_5, ±6.3 percent for TSS, and ±8.0 percent for O&G.

Table 2.—Daily composite samples—mechanized salmon processing canneries A and B.

Item	Unit	No.[1] of samples per day	Cannery	Waste concentration Mean	SD	Observed Min.	Observed Max.
BOD_5	mg/l	4	A	2,682	939	1,433	3,666
BOD_5	mg/l	12	B	2,490	901	1,347	3,970
TR	mg/l	4	A	3,198	760	2,090	3,760
TR	mg/l	14	B	3,607	1,036	2,720	5,660
TSS	mg/l	4	A	1,330	277	1,040	1,668
TSS	mg/l	13	B	1,575	719	460	2,735
FR	mg/l	4	A	1,868	587	1,050	2,429
FR	mg/l	13	B	2,020	752	867	3,348
O&G	mg/l	4	A	648	391	239	1,029
O&G	mg/l	10	B	687	475	246	1,653
TKN	mg/l	4	A	417	100	272	466
TKN	mg/l	10	B	388	152	280	641
COD	mg/l	4	A	4,462	1,247	2,928	5,782
COD	mg/l	10	B	5,348	2,268	3,434	9,900
$\frac{TSS}{TR}$	%	4	A	42.5	7.2	32.7	49.9
$\frac{TSS}{TR}$	%	13	B	43.6	15.4	16.4	67.9
$\frac{FR}{TR}$	%	4	A	57.5	7.2	50.1	67.3
$\frac{FR}{TR}$	%	13	B	56.4	15.4	32.1	83.6

[1] Results accepted when duplicate analyses were within the 95 percent confidence intervals established for these tests.

Waste Discharged for Each Unit of Production

Both canneries discharged less BOD_5, TSS, and O&G per unit of production on high-production days than on low-production days. Because the EPA effluent limitations (defined per unit of raw material processed) are the same for all levels of production, the untreated wastewater discharged by both canneries is below EPA recommended effluent limitations for BPTCA more frequently on high-production days than on low-production days (Fig. 4, 5).

The EPA limitations favored Cannery B (Table 3) which reported high-production days more frequently than Cannery A (Fig. 6). Cannery B, however, discharged more waste into the environment than Cannery A (Fig. 7).

Daily production levels are determined by the fishing intensity, weather conditions, and factors the canneries are unable to control. Quality would be lost if salmon were held to eliminate low-production days.

The relative errors for the determination of the amount of waste discharged for each limit of production were approximately ±14.7 percent for BOD_5,

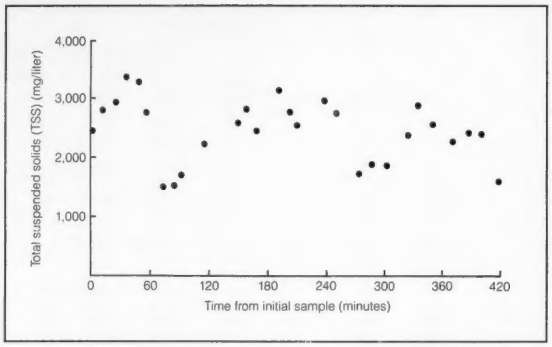

Figure 3.—Total suspended solids (TSS) concentration of intraday random samples from Cannery B, day 4.

Table 3.—Frequency of values less than EPA recommended effluent limitations for BPCTCA.

Item	Cannery	Daily max.	30-day avg.
BOD_5	EPA limit	N/A[1]	N/A
BOD_5	A	N/A	N/A
BOD_5	B	N/A	N/A
TSS[2]	EPA limit	44	26
TSS	A	76%	5%[3]
TSS	B	80%	40%
O&G[2]	EPA limit	29	11
O&G	A	95%[3]	76%
O&G	B	95%[3]	80%

[1]N/A = not applicable.
[2]Long-term estimates, in percent. EPA limits in pounds/1,000 pounds or kg/1,000 kg.
[3]Values of 5 percent and 95 percent represent the confidence interval justified by the data.

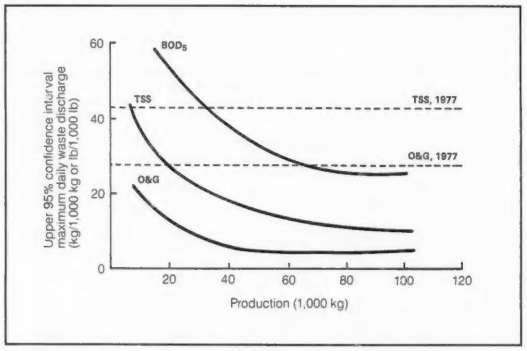

Figure 4.—Daily maximum waste discharge (upper 95 percent confidence interval vs. daily production and EPA guidelines for BPCTCA). Least squares regression curves fitting data for Canneries A and B.

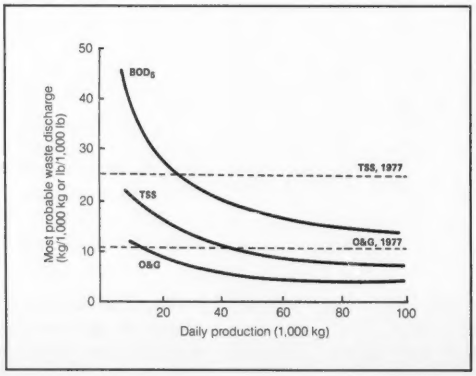

Figure 5.—Most probable waste discharge vs. daily production and EPA 30-day averages for BPCTCA. Least squares regression curve fitting data for Canneries A and B.

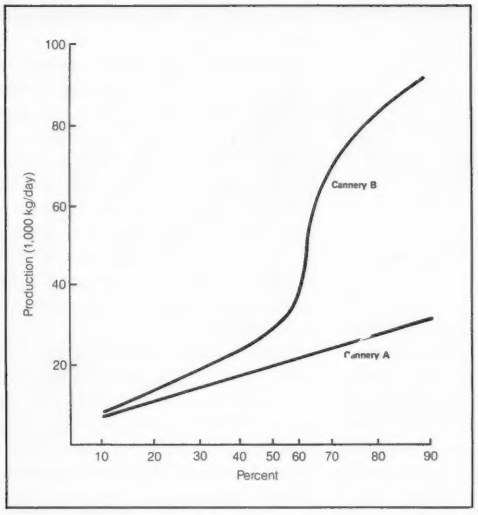

Figure 6.—The 1976 daily production at Canneries A and B. Frequency (percent) of values less than corresponding production.

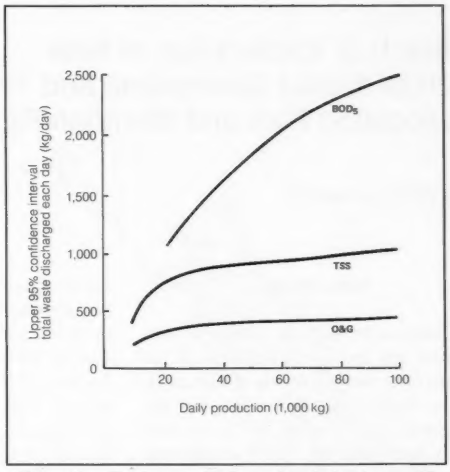

Figure 7.—Total waste discharged each day (upper 95 percent confidence interval) vs. daily production. Least squares regression curves fitting data for Canneries A and B.

±13.4 percent for TSS, and ±13.8 percent for O&G. At best, additional sampling would reduce but not eliminate sampling and analytical errors (Youden and Steiner, 1975).

Summary and Conclusions

Both canneries discharged less BOD_5, TSS, and O&G per unit of production as daily production increased. Values less than the EPA recommended effluent limitations became more frequent as production increased. The bias in favor of larger production is a strong case for basing guidelines on local environmental considerations rather than daily production values.

Variations in daily production, water use, and waste concentration values make it difficult to calculate precisely the amount of waste discharged for each unit of production. The relative errors for each of these measurements should be considered when enforcing guidelines.

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Initial U.S. Exploration of Nine Gulf of Alaska Seamounts and Their Associated Fish and Shellfish Resources

STEVEN E. HUGHES

ABSTRACT—The first U.S. exploration of fish and shellfish resources associated with nine Gulf of Alaska seamounts was conducted during 40 days in June and July 1979 from the 35-m crabber-trawler Sunset Bay. *The reconnaisance survey included detailed acoustic soundings to map seabed topography; determine the suitability of substrate for deploying a variety of fishing gears; and exploratory fishing with sablefish traps, king crab pots, bottom trawls, midwater trawls, and photographic gear to determine fish and shellfish species composition, their distribution, and relative abundance on and over the seamounts. Descriptions of each seamount (Dickens, Welker, Durgin, Pratt, Applequist, Surveyor, Quinn, Giacomini, and Patten) topography and seabed conditions, as determined from acoustic mapping, are presented along with fishery resource information for all but Applequist seamount. Species of commercial importance occurred primarily in the demersal community and included two species of king crab,* Lithodes couesi *and* L. aequispina*; snow (Tanner) crab,* Chionoecetes tanneri*; and sablefish,* Anoplopoma fimbria. *The pelagic community consisted primarily of low densities of highly diversified bathypelagic fishes and squids including several rare species of scientific interest.*

Introduction

Undersea mountains known as seamounts are prominent features of the ocean floor and are far more numerous in the Pacific than in the Atlantic and Indian Oceans. Larina (1975) reported the occurrence of 7,100 seamounts rising more than 0.5 km above the Pacific Ocean seabed. Pacific seamounts are primarily of volcanic origin concentrated in the central and western Pacific, but clusters of spectacular undersea mountains also occur along the northeastern North Pacific and Gulf of Alaska.

In addition to the often striking geological features of seamounts, which may rise abruptly from ocean basin depths of 4,000 m to within 20 m of the ocean surface, some seamounts are known to be inhabited by surprisingly large quantities of marine life for their relatively small surface areas. This has been convincingly shown by the recent development of large Japanese and Soviet fisheries over several seamounts in the central North Pacific, northwest of Midway Island. Takahashi and Sasaki (1977) and Sasaki (1978) reported Japanese catches of pelagic armorhead, *Pentaceros richardsoni*, and alfonsin, *Beryx splendens*, have averaged 20,000-30,000 metric tons (t) annually since 1972.

Catches have principally been obtained by trawlers operating on four seamounts west of Midway Island at long. 171°-179°E, lat. 30°-36°N. They also reported that Soviet trawl catches of armorhead and alfonsin in that area may have reached 130,000 t in 1969, and while Soviet operations have continued, more recent catches are unknown. Also indicative of the initial high armorhead and alfonsin densities over these seamounts, 1,500-4,000-ton Japanese trawlers averaged catch rates of 60.2 t/hour in 1972. Since that year, however, concern for stability of the resource has mounted due to constantly decreasing catch rates which, in 1976, were 16 t/hour.

Reports of the highly valued central North Pacific seamount fisheries of Japan and the U.S.S.R. prompted the first U.S. investigation of nine major seamounts, and their associated fishery resources, in the Gulf of Alaska during a 40-day period in June and July 1979. This report is a summary of the topography, partial water temperature profile, and general fishery resource information of the seamounts investigated.

Based on the location of the "200-mile line" established by the Fishery Conservation and Management Act of 1976, Dickens, Welker, Quinn, Giacomini, and Patten seamounts are located within the U.S. controlled fishery conservation zone and Durgin, Pratt, Applequist, and Surveyor seamounts are located outside that zone in international waters (Fig. 1).

Methods

Operations were conducted from the chartered 35 m (108 foot) trawler-crabber *Sunset Bay*. A variety of survey and fishing gear was operated in an exploratory mode designed to determine seamount topographic and temperature profiles and determine the distribution and composition of the pelagic and demersal fisheries community.

Large scale Loran-C work charts spanning the location of each seamount were prepared prior to the cruise and provided a means to map transected acoustic depth soundings, temperatures resulting from expendable bathythermograph (XBT) casts, location of trawl hauls, location of fixed gear, and comments on seabed hardness as interpreted from the acoustic soundings. After each seamount was mapped, fishing gear was deployed as dictated by seabed conditions. Bottom trawling to depths of 385 fathoms (fm) was completed with a high opening 32 m (105 foot)

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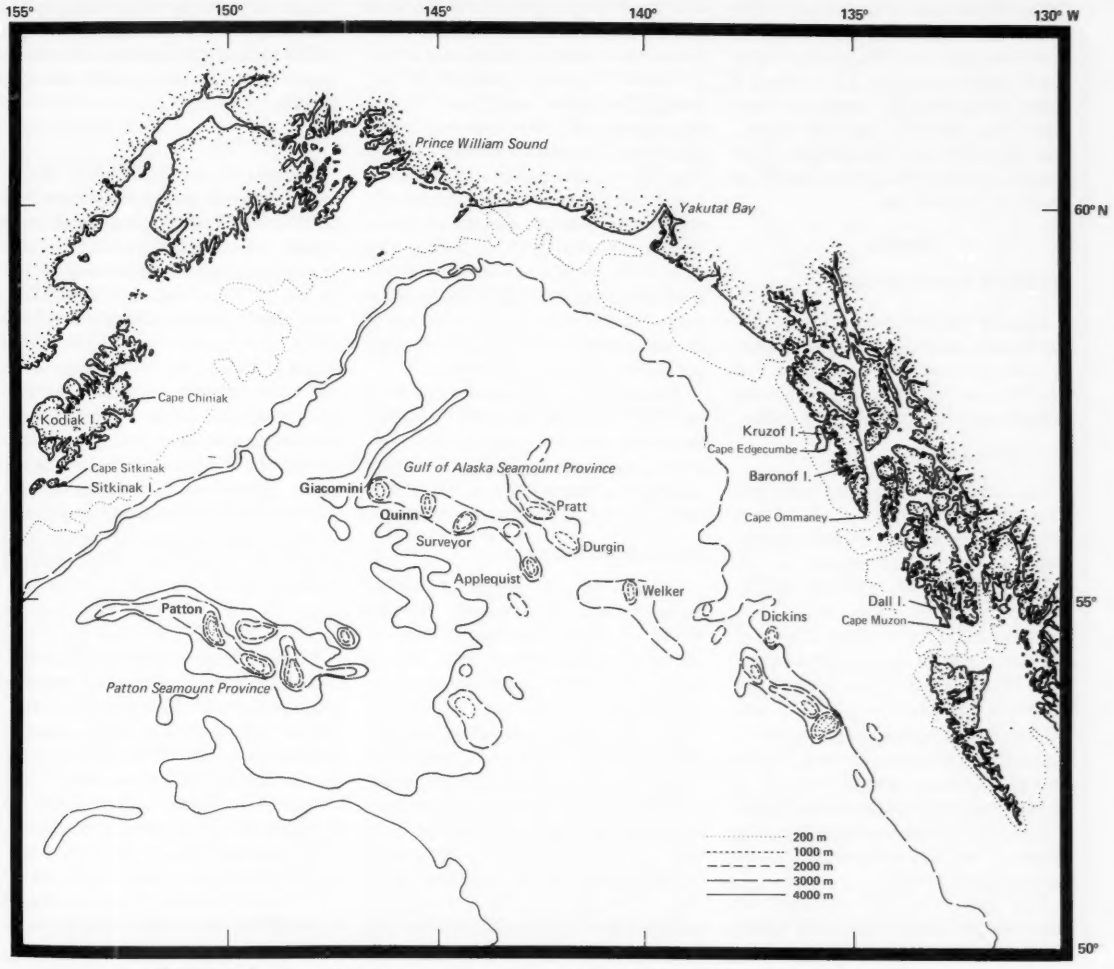

Figure 1.—Location of the nine seamounts surveyed in the Gulf of Alaska, 31 May-4 July 1979.

footrope Nor'easter[1] trawl equipped with rubber bobbins and a 32 mm (1¼ inch) mesh liner in the codend. Trawl doors used to spread the bottom trawl were 1.8 × 2.7 m (6 × 9 foot) steel V-type, each weighing about 1,045 kg (2,300 pounds). The midwater trawl net was of the east coast Canadian "Diamond" series (54 m, 177 foot footrope), equipped with a 32 mm (1¼ inch) mesh codend liner and was spread with 1.8 × 2.7 m (6 × 9 foot) Suberkrub-type doors weighing 540 kg (1,200 pounds) each.

Seventeen sablefish traps fished in strings on the seabed (Hipkins, 1974) were also used to sample the demersal fish and shellfish community. The traps were of both the Korean style 1.5 m (5 foot) diameter conical and U.S. style 2.4 m (8 foot) long rectangular design. Near the end of the survey, four 1.8 m (6 foot) square king crab pots were added to the trap strings to better sample crab populations which were encountered in surprisingly high quantities during the earlier survey period.

Deep sea still photography was conducted on Patton, Giacomini, and

[1]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

Quinn Seamounts (Raymore[2]). The underwater camera and light source were mounted to a triangular shaped metal frame suspended 2.5 m above a baited ballast weight which was lowered to the seabed. Using this system, time-lapse 35 mm photographs were obtained during 4½-6 hour periods at depths of 237-435 fm.

Results

Seamount Descriptions

Descriptions of the major topographical features of all nine seamounts (Fig. 1) were successfully completed and may be summarized as follows in order of their east to west trans-Gulf location.

Dickens Seamount

Located 145 nautical miles (nmi) true west of Cape Muzon (Dall Island) off southeastern Alaska, Dickens Seamount's center is positioned at lat. 54°31′18″N, long. 136°56′00″W. This seamount rises from abyssal plain depths of 1,600 fm to within 228 fm of the ocean surface at the central position. The top is rectangular in shape and measures approximately 2 × 5 nmi (10 nmi^2) with the long axis oriented in a northeast-southwest direction. Depths on top of Dickens ranged from 228 to 410 fm, with much of the 10 nmi^2 being at 230-300 fm. The substrate is patchy (areas of hard and soft sediment) with scattered rock pinnacles.

On 2 June 1979, XBT casts over the seamount indicated water surface temperatures of 8.5°C, a poorly defined thermocline at 16-27 fm, and a bottom temperature of 4.3°C. Over deep water adjacent to Dickens, surface temperatures ranged from 8.7° to 9.0°C, and a more discrete 3.5°C thermocline existed at 11-38 fm.

Welker Seamount

Located 120 nmi WNW of Dickens Seamount and approximately 201 nmi WSW of Cape Ommaney (Baranof Island) off southeastern Alaska, Welker Seamount's center is positioned at lat. 55°06′42″N, long. 140°20′36″W. Welker Seamount rises from abyssal plain depths of 1,900 fm to within 385 fm of the ocean surface at the east edge. The top is rectangular and measures 4 × 7 nmi (28 nmi^2) with the long axis oriented north-south. Depths on top of Welker ranged from 385 to 500 fm with most of the surface area at 420-450 fm. Rock pinnacles rising 5-20 fm high are very common over the entire surface of the seamount. Areas of soft substrate are common between pinnacles.

Temperature conditions derived from the XBT over and adjacent to Welker Seamount were very similar and typically displayed 8.0°-8.4°C surface readings, a thermocline at 11-38 fm, and 3.7°-4.2°C bottom temperatures.

Durgin Seamount

Located 60 nmi WNW of Welker Seamount and approximately 215 nmi WSW of Cape Edgecumbe (Kruzof Island) off southeastern Alaska, Durgin Seamount's center is positioned at lat. 55°50′00″N, long. 141°51′30″W. Durgin Seamount rises from abyssal plain depths of 1,900 fm to within 343 fm of the ocean surface near the center position of the top. Its top is rectangular, measuring approximately 4 × 7 nmi (28 nmi^2) with the long axis oriented in a northeast-southwest direction. The top is quite flat ranging primarily from 355 to 390 fm below the ocean surface. Rocky pinnacles and hard substrate are prominent features of the eastern half of the top, while soft sediment and occasional rock pinnacles are prominent over the western half.

Applequist Seamount

Located 36 nmi SW of Durgin Seamount and approximately 252 nmi WSW of Cape Edgecumbe (Kruzof Island) off southeastern Alaska, Applequist Seamount's center is positioned at lat. 55°28′30″N, long. 142°46′24″W. Applequist rises abruptly from abyssal plain depths of about 2,000 fm to within 388 fm of the ocean surface near the center position of the top. The top of this seamount consists primarily of one large, steep peak composed of hard substrate. While a minimum depth of 388 fm was determined, a maximum area of 1 nmi^2 occurs at depths less than 500 fm.

Pratt Seamount

Located 46 nmi true north of Applequist Seamount and approximately 229 nmi WSW of Cape Edgecumbe (Kruzof Island) off southeast Alaska, Pratt Seamount's center is positioned at lat. 56°14′22″N, long. 142°32′00″W. Pratt rises from abyssal plain depths of about 2,000 fm to within 385 fm of the ocean surface. The top is rather symmetrically shaped, measures 4 × 5 nmi, with most of the 20 nmi^2 of the top surface area being at depths of 400-450 fm. The seabed over the central and north central area is primarily soft substrate while the east, west, and southern edge areas consist of hard and soft patches of substrate with occasional rock pinnacles.

Surveyor Seamount

Located 58 nmi WSW of Pratt Seamount and approximately 235 nmi true south of Cape St. Elias (Kayak Island) Alaska, Surveyor Seamount's center is positioned at lat. 56°03′06″N, long. 144°19′20″W. Surveyor rises from abyssal plain depths of about 1,800 fm to within 200 fm of the ocean surface. This seamount has a relatively large, flat, oval surface comprising about 70 nmi^2. Depths within this area ranged from 200 fm atop a large rock pinnacle to 450 fm; however, most of the surface area was 300-350 fm. Soft substrate was extensive, particularly on the southwest and south sides. Rock pinnacles were present and most common on the north and east sides.

Quinn Seamount

Located 33 nmi WNW of Surveyor Seamount and approximately 220 nmi south of Cape St. Elias (Kayak Island), Alaska, Quinn Seamount's center is positioned at lat. 56°18′18″N, long. 145°13′07″W. Quinn rises abruptly from abyssal plain depths of about 2,000 fm to within 373 fm of the ocean surface. The top is rather oval, measures 3 × 4 nmi with most of the 12

[2]Raymore, P. 1979. Deep-sea floor photography on Gulf of Alaska seamounts. Northwest and Alaska Fisheries Center Monthly Report, December, p. 9-19. Northwest and Alaska Fisheries Center, NMFS, NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

nmi^2 surface being 400-450 fm below the surface. This seamount is characterized by considerable soft sediment, an apparent absence of rock pinnacles, and extremely steep edges which plunge to the abyssal plain.

Giacomini Seamount

Located 40 nmi west of Quinn Seamount and approximately 198 nmi ESE of Cape Chiniak (Kodiak Island), Alaska, Giacomini Seamount's center is positioned at lat. 56°27′30″N, long. 146°24′00″W. Giacomini rises from abyssal plain depths exceeding 2,000 fm to within 367 fm of the ocean surface. This seamount has a rather symmetrical flat-topped shape comprised of about 20 nmi^2 of surface area at depths primarily of 370-400 fm. The substrate is predominantly soft with scattered rock pinnacles.

Patton Seamount

Located 175 nmi SW of Giacomini Seamount and approximately 166 nmi SE of Cape Sitkinak (Sitkinak Island), Alaska, Patton Seamount's center is positioned at lat. 54°34′22″N, long. 150°29′30″W. Patton rises from abyssal plain depths exceeding 1,900 fm to within 100 fm of the ocean surface at the NE corner of the seamount's top. The topographical features of Patton are much different from the previously described seamounts. The top measures 4 × 6 nmi; however, the 24 nmi^2 surface area consists of an endless series of rocky mountain peaks and canyons ranging from 100 to 500 fm depths. Areas at depths less than 200 fm are primarily mountain peaks. Areas of relatively flat and soft substrate are uncommon but occur mainly over the southwest quadrant.

Seamount Fish and Shellfish Resources

The survey of fish and shellfish resources associated with the seamounts yielded considerable information of commercial and scientific value. Data on fish and shellfish communities were obtained from all seamounts except Applequist, where the topography prevented use of traps and bottom trawling.

Table 1.—Sablefish and crab catches by trap-pot type obtained on the eight Gulf of Alaska seamounts fished from 31 May to 5 July 1979.

Seamount and date	No. and type of traps/pots fished	Avg. hours on the bottom	Depth range fished (fm)	Catch							
				Sablefish *Anoplopoma fimbria*		Crab					
						L. couesi		*L. aequispina*		*C. tanneri*	
				no.	lb	no.	lb	no.	lb	no.	lb
Dickens 5/31/79-6/1/79	2 conical 5 rectangular	14.5	260	44	207	8	—	1	—	0	0
Durgin 6/11/79	5 conical 5 rectangular	13.5	380-390	30	150	29	24	0	0	28	19
Giacomini 7/1/79-7/4/79	16 conical 17 rectangular 8 king crab	27.0	372-380	197	1,211	653	492	0	0	465	330
Patton 6/25/79-6/30/79	20 conical 13 rectangular 4 king crab	21.0	200-369	128	1,014	473	378	157	188	48	50
Pratt 6/12/79-6/13/79	8 conical 10 rectangular	18.0	425-450	25	125	17	17	0	0	33	25
Quinn 6/18/79-7/5/79	13 conical 13 rectangular 4 king crab	22.0	398-475	202	1,537	95	90	0	0	183	228
Surveyor 6/13/79-6/17/79	32 conical 36 rectangular	18.0	328-395	137	924	121	95	19	19	112	103
Welker 6/3/79-6/5/79	6 conical 15 rectangular	12.0	426-435	222	1,122	38	30	0	0	94	86

Dominant species of commercial value were found on or near the seamount substrates rather than in midwater over or adjacent to the seamounts. These species consisted of sablefish, *Anoplopoma fimbria*; deep-sea red king crab, *Lithodes couesi*; golden king crab, *L. aequispina*; and snow (Tanner) crab, *Chionoecetes tanneri*. The distribution and relative abundance of these species was most adequately assessed by trap and pot gear. Table 1 summarizes sablefish and crab catches in weight and numbers by seamount.

Sablefish, which is a dominant demersal species of the lower continental shelf and upper slope throughout the Gulf of Alaska, appeared from trap and pot catches to be the dominant finfish of each seamount's demersal fish community. Although bottom trawling was generally ineffective due to hang-up or excessive depths, 15 bottom trawl hauls on Durgin, Patton, Surveyor, and Welker Seamounts also produced catches dominated in weight by sablefish, with lesser amounts of rattails: *Coryphaenoides pectoralis*, *C. acrolepis*, and *C. cinereus*. Based on the trap and pot catches, there was also an indication that sablefish abundance on the seamounts was increasing during the June-July survey period. This was most notable on Quinn Seamount, the only seamount revisited, where initial 18 June sablefish catches produced 30 fish weighing 210 pounds from nine traps during a 20-hour period on the bottom (soak) (1.2 pounds/trap per hour), compared with 4 and 5 July catches of 172 sablefish weighing 1,327 pounds from 19 traps during a 23-hour soak (3.0 pounds/trap per hour).

Essentially all sablefish captured were ripe, spawning, or recently spent. Males outnumbered females by over 2:1. The length composition of 653 males and 310 females sampled from the combined seamount sablefish catches is shown in Figure 2.

While the occurrence and abundance of sablefish on the seamounts were not surprising due to their abundance at similar depths on the adjacent continen-

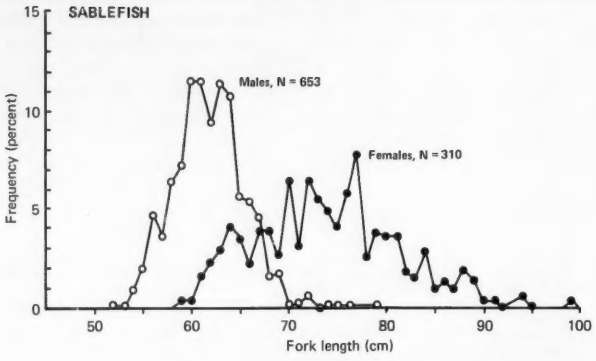

Figure 2.—Length-frequency distribution and sex ratio of sablefish obtained from collective catches on eight seamounts in the Gulf of Alaska during 31 May-4 July 1979.

tal shelf and slope in the Gulf of Alaska, the occurrence, abundance, and species diversity of crab on the seamounts were unexpected. This is best illustrated by comparing seamount crab catches with those obtained from nearly identical trap gear on the southeastern Alaska continental shelf and slope waters to assess sablefish stock abundance. In addition to gear similarities, the survey off southeastern Alaska was conducted at lat. 54°-58°N which spans the seamount locations, covers a similar depth range (150-450 fm), and was conducted during June and July of 1978 and 1979. During the 1978-79 survey off southeastern Alaska, 1,500 trap catches produced 62 deep-sea red king crab, 0 golden king crab, and 143 snow (Tanner) crab. By comparison, 232 seamount trap-pot catches (Table 1) produced 1,434 deep-sea red king crab, 177 golden king crab, and 963 snow (Tanner) crab.

Comparing catches between seamounts, the deep-sea red king crab displayed the widest distribution occurring on all seamounts, followed by snow (Tanner) crab which was obtained on seven of the eight seamounts, and the golden king crab which occurred on only Dickens, Patton, and Surveyor Seamounts. Patton Seamount, which provided the most rocky and irregular substrate as well as the shallowest depths fished, supported the most dense and diversified crab community. Figure 3 summarizes the size composition by sex and percentage sex composition obtained from the collective seamount crab catches. Many females of each crab species were carrying maturing clutches of eggs.

The underwater camera system successfully photographed crab populations on the seamounts (Fig. 4). This system was used five times, once on Patton Seamount and twice each on Giacomini and Quinn Seamounts.

Trawl sampling of the seamount communities was intended primarily to target on acoustically detected fish concentrations. However, extensive acoustic soundings of the water columns above and adjacent to the seamounts, as well as near the seamounts' substrates, failed to locate notable fish concentrations. Accordingly, trawling was conducted on bottom and in three midwater zones (zone 1 at 300-340 fm; zone 2 at 90-235 fm; and zone 3 at 7-18 fm) in an attempt to sample the apparent low density of acoustically undetected organisms near bottom and within the water column.

Catches resulting from the 15 bottom hauls and 17 midwater hauls completed on and over Dickens, Surveyor, Quinn, and Patton Seamounts generally produced low quantities of noncommercially valuable species but did produce catches representing a wide species diversity of considerable scientific interest. Table 2 lists those species obtained by respective seamount depth zones sampled. Perhaps the rarest fish obtained was the winged spookfish, *Dolichopteryx* sp., previously known only from one specimen in the North Pacific which was obtained at ocean station "Papa" (lat. 50°N, long. 145°W) in September 1969 (Hart, 1973). Hart further noted the specimen obtained at ocean station Papa probably represented an undescribed species, that it probably represented the largest specimen of the genus captured (154 mm TL) and that the genus is represented by a few rare species, mostly from the Atlantic Ocean. During the seamount survey, five spookfish, ranging in length from 130 to 200 mm FL were obtained from a midwater tow over Quinn Seamount at depths of 300-310 fm on 19 June 1979. An additional specimen measuring 200 mm FL was obtained from Patton Seamount 26 June 1979 at midwater depths of 285-305 fm.

A second species of the spookfish family captured during the seamount survey was the barreleye, *Macropinna microstoma*, which Hart (1973) described as an uncommon species occurring from northern Baja California to the Gulf of Alaska. The largest specimen previously reported was 44 mm in length. Sixteen barreleye ranging in length from 60 to 140 mm FL were obtained on Surveyor and Quinn Seamounts. All specimens were captured in bottom trawl or zone 1 midwater trawl hauls.

Specimens of the uncommon species included in Table 2 have been lodged at the University of Washington's College of Fisheries museum for further study.

Summary and Conclusions

Survey of the nine Gulf of Alaska seamounts has provided descriptive information on each seamount size, topographical characteristics, and associated pelagic and demersal fish and shellfish resources.

Although the crest of Applequist Seamount rises steeply to a terminal single peak, the crests of Dickens, Welker, Durgin, Pratt, Surveyor, Quinn, Giacomini, and Patton Seamounts are rather flat and range in size from 10 to 70 nmi^2. Hence, these seamounts, with the exception of Patton which has a highly irregular crest, might be more properly termed "gyotes."

Except for the predominantly rocky and irregular crest on Patton, the crests of the remaining seven seamounts or gyotes are generally composed of soft substrate with scattered rock pinnacles rising 5-20 fm above the tops. The presence of such pinnacles hampered the effectiveness of bottom trawling for demersal fauna, while traps and pots proved to be effective gear for sampling demersal fish and shellfish resources on the substrates encountered.

Commercially valuable species encountered (sablefish, deep-sea red king crab, golden king crab, and snow (Tanner) crab) were members of the demersal faunal community. The pelagic community consisted of low densities of noncommercially valuable squid and small bathypelagic fishes and immature salmon.

Catches obtained by traps indicated sufficient sablefish densities to support commercial harvest of this species using either traps or longline gear as presently fished on the adjacent continental shelf and slope areas in the Gulf of Alaska and the northeast Pacific coast. More detailed and quantitative resource assessment surveys would be required to determine the magnitude of this resource and its potential annual sustained yield. Also, while sablefish encountered on the seamounts were in spawning condition, it is not known whether this population represents a self-sustaining resident stock independent of the coastal stock.

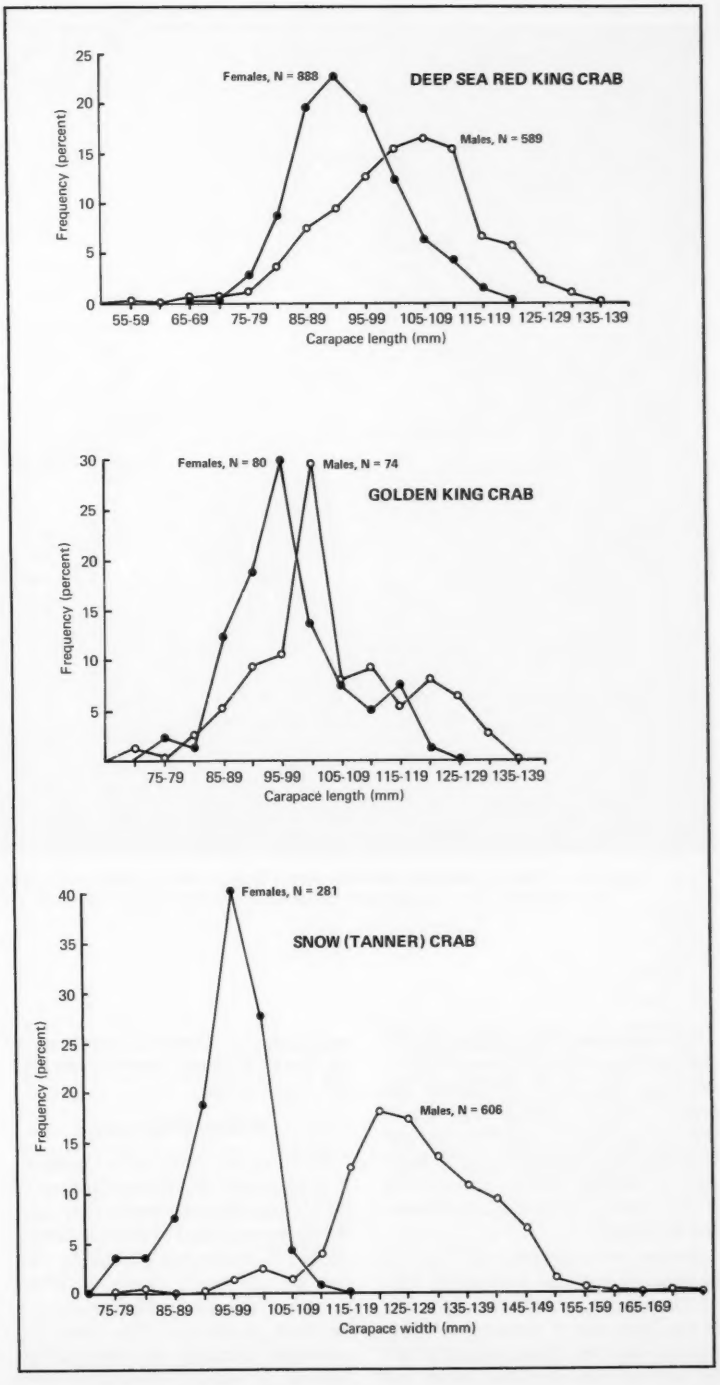
DEEP SEA RED KING CRAB
Females, N = 888
Males, N = 589
Frequency (percent)
Carapace length (mm)
55-59 65-69 75-79 85-89 95-99 105-109 115-119 125-129 135-139
GOLDEN KING CRAB
Females, N = 80
Males, N = 74
Frequency (percent)
Carapace length (mm)
75-79 85-89 95-99 105-109 115-119 125-129 135-139
SNOW (TANNER) CRAB
Females, N = 281
Males, N = 606
Frequency (percent)
Carapace width (mm)
75-79 85-89 95-99 105-109 115-119 125-129 135-139 145-149 155-159 165-169

Figure 3.—Carapace size composition and sex ratios of deep-sea red king crab, golden king crab, and snow (Tanner) crab obtained from collective trap and pot catches on eight seamounts in the Gulf of Alaska during 31 May-4 July 1979.

Figure 4.—Deep-sea red king crab and snow (Tanner) crab on Giacomini Seamount at 377 fm, 3 July 1979. Several animals are feeding on organisms obtained on or under the soft substrate. (NMFS photo by Paul Raymore.)

The occurrence and apparent significant densities of king and snow crab on the seamounts were unexpected and proved to be a notable discovery of the survey. Due to the commercial value of these species, it may be desirable to conduct further quantitative studies of their distribution, abundance, and life history.

Studies are continuing on the collections of rare and uncommon fish, squid, octopus, and shrimp, presently at the University of Washington's College of Fisheries. These collections are of considerable scientific value and may represent numerous extensions to known geographic distributions and size composition.

Acknowledgments

For many years prior to his December 1979 retirement as Assistant Director of the National Marine Fisheries Service's Northwest and Alaska Fisheries Center, Alonzo T. Pruter had planned to conduct an exploratory survey of fishery resources associated with seamounts in the Gulf of Alaska. This study was conducted primarily as a result of his interest. It was my pleasure to work with "Al" for many years prior to this survey and to join him on his last cruise as a fishery biologist with the Northwest and Alaska Fisheries Center.

Thanks are also expressed to Olf Austenberg, Captain of the chartered vessel *Sunset Bay*, and his crew for excellent cooperation during the survey.

Table 2.—Fish, crustaceans, and cephalopods obtained by trawl on and over five seamounts in the Gulf of Alaska. BT signifies bottom trawl, MT1 signifies midwater trawl at depth of 300-340 fm, MT2 signifies midwater trawl at depth of 90-235 fm, and MT3 signifies midwater trawl at depth of 7-18 fm. (*) = bottom trawl that may not have been on bottom at all times.

Species	Seamounts					
	Dickens	Welker	Durgin	Surveyor	Quinn	Patton
Fish						
Anoplopomatidae						
Anoplopoma fimbria	—	BT	BT	BT	—	BT
Argentinidae						
Nansenia candida argentine	—	—	—	MT1	MT1	—
Bathylagidae						
Bathylagus milleri	—	BT* BT	BT* BT	MT1	MT1	MT1
B. pacificus deep	—	—	—	BT MT1	MT1	MT1
Leuroglossus stilbius schmidti sea smelt	—	—	—	MT1	MT1	MT1
Chauliodontidae						
Chauliodus macouni	MT2	BT* BT	BT* BT	MT2, BT MT1	MT1	MT1 MT2
Cyclopteridae						
Aptocyclus ventricosus	—	—	—	BT	MT1, MT3	MT1 MT2
Icosteidae						
Icosteus aenigmaticus	—	—	BT*	—	—	—
Macrouridae	—	BT	—	—	—	—
Coryphaenoides acrolepsis	—	—	BT	BT	—	BT
C. cinereus	—	BT	BT	BT	MT1	BT
C. pectoralis	—	BT	BT	BT	—	BT MT1
Melamphaeidae						
Poromitra crassiceps	—	BT	BT* BT	BT MT1	—	—
Melamphaes lugubris	—	BT	BT* BT	BT MT1	—	MT1
Melanostomiatidae						
Tactostoma macropus	—	BT*	BT*	BT MT1	MT1	—
Moridae						
Antimora microlepis	—	BT	—	BT	—	—
Myctophidae	MT2	—	—	MT2	MT3	MT2 MT1
Diaphus theta	MT2	BT	BT*	MT1 MT2	—	—
Lampanyctus regalis						
Protomyctophum thompsoni	MT2	—	—	—	—	MT1
Stenobrachius leucopsarus	MT2	BT* BT	BT* BT	MT2 BT, MT1	—	MT1 MT2
Nemichthyidae	—	—	—	BT MT1	—	MT1
Aricotena bowersi	—	—	BT*	—	—	
Oneirodidae					MT1	MT2
Oneirodes thompsoni	—	BT	—	MT1	—	—
Opisthoproctidae						
Dolichopteryx sp.	—	—	—	—	MT1	MT1
Macropinna microstoma	—	—	—	BT MT1	MT1	MT1
Oreosomatidae						
Allocytus verrucosus	—	—	—	MT2	—	—
Paralepididae						
Notolepis rissoi rissoi	—	—	—	MT1	MT1	—
Pleuronectidae						
Embassichthys bathybius	—	—	—	BT	—	BT
Salmonidae						
Oncorhynchus gorbuscha	—	—	—	MT3	—	MT3
O. keta	—	—	—	MT3	MT3	MT3
O. nerka	—	—	—	MT3	—	MT3
Scopelarchidae						
Benthalbella dentata	—	—	—	BT MT1	MT1	MT1
Scopelosauridae						
Scopelosaurus harryi	—	—	—	MT1	MT1	MT1
Scorpaenidae						
Sebastolobus altivelis	—	BT	BT	BT	—	BT
Searsidae						
Sagamichthys abei	—	—	—	MT1	MT1	—
Zaproridae						
Zaprora silenus	—	—	—	—	MT3	MT3
Zoarcidae						
Bothrocara remigerum	—	BT	—	—	—	—
Invertebrates						
Lithodidae						
Lithodes aequespina	—	—	—	BT	—	—
L. couesi	—	—	BT	BT	—	BT
Majidae						
Chionoecetes tanneri	—	—	BT	BT	—	
Bolitaenidae						
Japetella heathi	—	—	BT*	MT1	MT1	MT1
Octopus (unidentified)	—	—	—	MT2 BT		
Vampyroteuthidae						
Vampyroteuthis infernalis	—	—	—	—	MT1	—
Chiroteuthidae				MT1		
Chiroteuthis sp.	—	—	—	—	MT1	MT1
Cranchiinae	—	BT	—	MT1	—	—
Species A	—	—	—	—	MT1	MT1
Species B	—	—	—	—	MT1	MT1
Gonatidae	—	—	BT* BT	MT1	MT1	MT1 BT
Gonatus sp.	—	—	—	—	MT1	MT1
Octopoteuthidae	—	BT	—	MT1	—	—
Octopoteuthis sp.	—	—	—	—	MT1	—
Squid (unidentified)	MT2	BT	BT	BT MT3, MT2	MT3	—
Pasiphaeidae						
Pasiphaeia pacificus	—	BT	BT* BT	BT MT1	MT1	MT1
Mysidae						
Gnathophausia gigas	—	—	—	MT1	MT1	MT1

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Marine Fisheries Advisory Committee Members Named

Secretary of Commerce Philip M. Klutznick has named 10 people to the department's Marine Fisheries Advisory Committee. The committee advises the secretary on fishery activities carried out by the department's National Oceanic and Atmospheric Administration (NOAA).

The advisory group deals with such issues as international fisheries, aquaculture, biological and environmental research, fisheries technology, administration of the Marine Protection and the Endangered Species acts, and fishery management issues associated with extended fisheries jurisdiction.

The new appointees are: Alan J. Beardsley, Market Foods, Kodiak, Alaska; Sarah Chassis, Natural Resources Defense Council, Inc., New York, N.Y.; Maumus F. Claverie, Jr., New Orleans, La.; Joel Dirlam, professor of economics, University of Rhode Island, Kingston, R.I.; Charlotte Newton, Virginia Citizens Consumer Council, Springfield, Va.; Francisco Pagan-Font, executive director, Marine Resources Development Corporation, San Juan, Puerto Rico; Elizabeth Stromeyer, secretary-treasurer, Red Top Sporting Goods, Inc., Buzzards Bay, Mass.; Elizabeth L. Venrick, assistant research biologist, Scripps Institution of Oceanography, La Jolla, Calif.; and Walter W. Walkinshaw, Seattle, Wash. Ann McDuffie, food editor, Tampa Tribune, Tampa, Fla., has been reappointed for a second term.

Committee members are chosen for 3-year terms on the basis of their competence and proven interest in U.S. marine fishery resources. Members are also chosen with a view toward achieving balanced geographical, and public and private sector representation on the committee.

Massive East Coast Fish Kill Reviewed

A massive fish kill similar to the 1976 New Jersey disaster that destroyed an estimated $550 million worth of fish and shellfish could occur in the future, a new Federal report concludes.

The report, by the Commerce Department's National Oceanic and Atmospheric Administration (NOAA), notes that while nothing can be done to prevent sea and weather conditions which caused the 1976 kill, better long-range forecasting could minimize their effect on commercial fishing.

The 1976 kill occurred from July through October in an 8,600 km^2 area off the New Jersey continental shelf. Chief losses were among shellfish, especially surf clams, ocean quahogs, scallops, and lobsters. The report attributes the disaster to a severe depletion of oxygen and the formation of hydrogen sulfide in the water. Among the contributing factors were high temperatures, abnormal river runoff, a decline in spring and summer storm activity, and 4-6 weeks of unusually persistent south and southwest winds. These conditions caused a warming of the ocean's surface waters and a massive blooming of a small marine organism which consumed much of the diminished oxygen supply. The report also said that sewage and manmade pollutants contributed to the problem, but were not a determining factor.

The 345-page report, "Oxygen Depletion and Associated Benthic Mortalities in New York Bight, 1976," was edited by R. Lawrence Swanson of NOAA's Office of Marine Pollution Assessment and Carl J. Sindermann of NOAA's Northeast Fisheries Center Sandy Hook Laboratory, Sandy Hook, N.J. It is GPO Stock No. 003017004643, available from the Superintendant of Documents, U.S. Government Printing Office, Washington, D.C. 20402, at a cost of $8.50.

NMFS Creates Signal Code for U.S.-Japan Fishermen

United States and Japanese longline fishing operations in the Gulf of Mexico have at times encountered serious gear conflict and communications problems. Upon crossing the fishing line of another vessel or accidently damaging the line, the skipper of the vessel involved has frequently not been able to alert the other vessel because of a language barrier. Japanese and U.S. skippers are unable to read or understand the other's language. In the last year, the National Marine Fisheries Service has received many complaints regarding this problem.

To alleviate the problem, the NMFS Law Enforcement Division (LED), Southeast Region, has developed a signal system composed of three-letter character codes. The codes are structured so that each indicates whether it has message information or fishing line information. Included with the codes is the phonetic alphabet and cardinal numbers (0-9) used within the system. Also, there is an explanation of how the letters and numbers should sound when spoken. The codes are kept simple so that they can be read and understood when pronounced properly.

Copies of the first draft of the code system were sent to the Japanese Fisheries Association and certain U.S. longline skippers for their study and comments. The response was favorable and gratifying in that they are planning to test the system for its effectiveness during the next bluefin tuna season.

The Japanese Fisheries Association returned a copy of the original draft

with several additional suggested codes to further assist in resolving conflicts. Also, under each code symbol it supplied Japanese translations along with verbal pronunciation and meaning.

C. Peter Marini, LED Communication Management Specialist, remarks that although changes may be necessary to make the system totally effective, this is the first step toward resolving this particular communications problem.

NOAA RESEARCH SHIP CHAPMAN *COMMISSIONED*

A new Government research vessel, equipped with the latest electronic fish-finding instrumentation, has been commissioned by the National Oceanic and Atmospheric Administration at Seattle, Wash. Joining 25 other vessels in the NOAA fleet, the 127-foot NOAA Ship *Chapman*, is the first new vessel built for the Commerce Department agency since it was established 10 years ago.

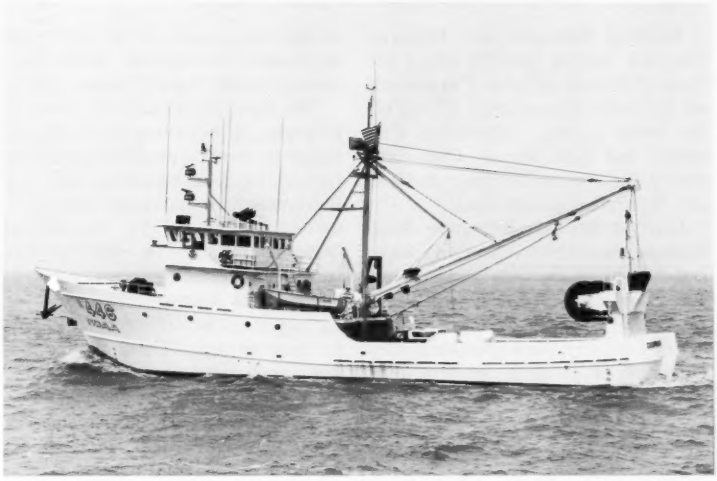
The $3.8 million vessel is based at NOAA's Pacific Marine Center where it will support stock assessments in the North Pacific 200-mile fisheries zone. In addition to modern electronic equipment, it will use conventional types of commercial fishing gear, including bottom trawls, midwater trawls, bottom and surface longlines, gill nets, and pot fishing. The ship also has two research laboratories, can accommodate an 8 × 20-foot portable scientific van, and has accommodations for 12 crew and 6 scientists.

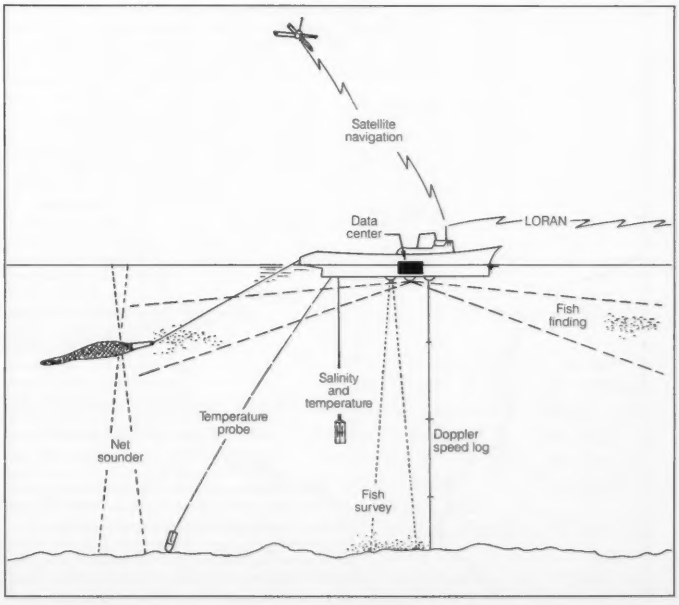
With a beam of approximately 30 feet, the *Chapman* has a 14-foot draft, a power plant that will deliver 1,250 shaft hp at 1,225 rpm, and a range of 6,000 miles at 11 knots.

Characteristics of the Class IV fisheries research ship are: Length, overall, 127 feet; Length, design waterline, 113 feet; Beam, 30 feet; Full load displacement, 520 tons; Draft full load, 14 feet; Fuel oil capacity (max.), 40,000 gallons; Freshwater + 800 gal./day, 4,700 gallons; Cruising radius @ maximum fuel, 6,000 nautical miles; and Speed, 11 knots.

Propulsion: Single crew, 1,250 SHP with a controllable pitch propeller and fixed Kort nozzle and a 150 hp jet-type bow thruster.

Electrical power: Two diesel powered, 210 kW prime rated, 480-volt, 3-phase, 4-wire, 60-cycle generators and one 17.5 kW emergency generator.





New Brazilian Lobster Grounds Harvested

Brazilian fishermen have begun to fish new lobster grounds along the coast of the state of Bahia. The grounds are reportedly located about 300 km off the towns of Una, Canavieiras, Belmonte, and Porto Seguro. Over forty vessels deployed on the new grounds in late 1979 reported high yields.

Most of the fishermen have come from the states of Rio Grande do Norte and Paraíba, along with smaller numbers from Ceará[1]. The fishermen report that they can catch as much lobster during 1 day on the new grounds as they previously caught during an entire week on their old grounds. In the first month of extensive commercial fishing effort catches totaled about 80 metric tons(t).

The state government of Bahia is interested in promoting the fishing industry to increase employment opportunities for local residents since the Bahians were not involved in the commercial lobster fishery. The Bahian Government, through offers of free land and financial assistance, hoped to attract firms interested in processing the lobsters in Bahia, thus creating jobs for local residents. Currently, the lobsters are landed at Canavieiras and Porto Seguro. There is a small domestic market created by local hotels, but most of the catch is immediately packed in insulated boxes. The lobsters are then trucked to the port of Natal in Rio Grande do Norte state where they are processed for export, primarily to the United States. Bahia officials would like for the processing to be done within the state.

The Brazilian fisheries agency (SUDEPE) is also interested in the new grounds. SUDEPE is charting the grounds and SUDEPE technicians plan to study the lobster population to determine if any restrictions on the catch are needed to protect the stocks. Brazilian lobster regulations are currently not enforced off Bahia because the lobster fishery was previously a small-scale activity conducted by a small number of artisanal fishermen. The commercial fishermen who come from the states of Rio Grande do Norte and Paraíba assure SUDEPE that they are abiding by all lobster fishing regulations. They return berried and juvenile[2] lobsters to the sea and bring the lobster heads[3] back to port where they are distributed free to anyone who wants them[4]. The Rio Grande do Norte and Paraíba fishermen, however, accuse fishermen from the state of Ceará, who generally have larger vessels, of not complying with those regulations, especially the one prohibiting fishermen from dumping the lobster heads overboard on the fishing grounds.

The National Marine Fisheries Service published a detailed background report on the Brazilian lobster industry in 1979, "The Brazilian Lobster Industry, 1976." A copy can be purchased for $5.00 by ordering report number DIB-79-03-05 from NTIS, Springfield, VA, 22161. (Source: IFR-80/93.)

[1] Ceará is the center of the Brazilian lobster industry.

[2] Lobsters with tails less than 12 cm.

[3] The lobsters are deheaded at sea and preserved on ice. SUDEPE officials discourage the fishermen from dumping the heads on the grounds as the live lobsters avoid areas littered with large quantities of dead lobsters and the severed heads also attract sharks making it dangerous for the fishermen to work the grounds.

[4] Many villagers await the return of the fishermen. Some come to pick up orders placed the day before. Others come to get free lobster heads for cooking and one teenager places the lobster heads he obtains on anthills to clean them and then uses them to make jewelry.

Japanese Shrimp Import Trends, 1963-79, Noted

Japanese imports of frozen shrimp in 1979 registered an all-time high in both quantity and value with 158,672 metric tons (t) at ¥ 301,171 million (US$1,375 million at ¥ 219= US$1), according to the customs clearance data released by the Japanese Finance Ministry. The 1979 imports surpassed the previous high of 143,962 t and $999 million set in 1978. The import price averaged for the year, at ¥ 1,898/kg ($3.94/pound), was also a new record.

Since Japan liberalized its shrimp imports in 1961, purchases from foreign countries rose year after year save for brief lapses in 1968 and 1974. Shrimp imports in 1979 represented more than a thirteenfold increase over 1963. Annual import volumes in excess of 100,000 t have been maintained since 1973. Up to 1970, Mexico and Mainland China were major suppliers of shrimp to Japan. Since 1971, however, India and Indonesia have been leading suppliers and in 1979 these two countries together accounted for 43 percent of Japan's total shrimp imports. Mainland China was the third and Mexico the seventh major supplier in 1979, each with 12,082 t and 4,727 t, respectively.

Other important suppliers in 1979 were Australia with 10,955 t, Thailand with 9,294 t, Taiwan with 5,998 t, Hong Kong with 4,365 t, and Pakistan with 4,179 t. Imports for the year were also at a record high from India, Indonesia, Mainland China, Taiwan, Iran, Australia, Philippines, Sabah, Brazil, and Bangladesh. Imports from the United States were 285 t. (Source: FFIR 80-8.)

Japanese frozen shrimp imports (t) by country of origin, 1974-79.

Country of origin	1974	1975	1976	1977	1978	1979
India	19,898	29,942	26,901	25,803	31,580	38,757
Indonesia	19,385	21,060	25,510	25,701	28,338	29,621
China, Mainland	9,483	9,768	5,569	3,749	9,197	12,082
Mexico	4,580	4,085	5,235	4,184	7,860	4,727
Thailand	6,314	8,837	9,849	2,760	8,377	9,294
China, Taiwan	3,245	3,395	3,241	4,389	5,567	5,998
Pakistan	2,305	2,951	3,892	3,889	3,675	4,179
Korea, South	3,127	2,932	4,673	2,574	2,461	2,219
Malaysia	2,619	2,392	3,877	3,392	2,827	3,131
Iran	854	651	803	515	815	996
Australia	5,189	4,663	6,189	7,742	7,546	10,955
Hong Kong	4,051	4,140	4,627	5,993	4,608	4,365
Cuba	3,193	3,548	1,693	1,417	919	1,125
Kuwait	236	379	1,031	572	635	485
Vietnam	2,154	1,639	2,356	2,760	2,411	1,794
Philippines	1,521	1,109	2,081	2,393	2,791	3,701
Nigeria	771	867	831	1,060	1,060	564
Sabah	1,728	1,515	2,296	2,505	2,328	2,728
Bahrain	1,227	1,014	974	1,041	1,031	239
Brazil	855	391	770	1,595	2,597	2,921
Liberia	611	330	320	270	212	181
Guyana	762	939	900	1,067	1,176	875
Camaroons	809	474	386	217	88	170
Singapore	517	345	336	489	374	326
United States	130	68	332	454	479	285
Bangladesh	220	339	565	865	1,170	1,694
U.S.S.R.	1,294	0	0	0	1,861	261
Total (including other countries)	103,311	113,672	123,334	124,780	143,962	158,672

Japanese frozen shrimp imports (in metric tons, value in US1,000), by leading countries, 1963-79.

Year	India	Indonesia	China[1]	Mexico	Total[3]	Value
1963	n.a.[2]	n.a.	n.a.	n.a.	11,708	23,475
1964	n.a.	n.a.	n.a.	n.a.	18,167	31,437
1965	851	n.a.	5,875	5,210	21,011	35,938
1966	993	n.a.	11,769	4,889	36,156	60,085
1967	2,147	15	5,004	7,995	44,466	79,732
1968	3,164	661	3,769	5,769	35,204	78,079
1969	4,864	2,604	4,136	5,511	48,886	121,748
1970	6,210	3,684	6,248	7,210	57,146	137,026
1971	9,702	8,223	4,990	6,520	78,874	214,591
1972	12,812	13,824	3,519	5,407	88,120	291,943
1973	21,903	18,764	4,475	8,839	117,474	429,845
1974	19,898	19,385	9,483	4,580	103,311	404,024
1975	29,942	21,060	9,768	4,085	113,672	464,527
1976	26,901	25,510	5,569	5,235	123,334	738,986
1977	25,803	25,701	3,749	4,184	124,780	790,806
1978	31,580	28,338	9,197	7,860	143,962	998,581
1979	38,757	29,621	12,082	4,727	158,672	1,375,210

[1] Mainland China
[2] n.a. = not available
[3] Total is for all countries.

Note: Unless otherwise credited, material in this section is from either the Foreign Fishery Information Releases (FFIR) compiled by Sunee C. Sonu, Foreign Reporting Branch, Fishery Development Division, Southwest Region, National Marine Fisheries Service, NOAA, Terminal Island, CA 90731, or the International Fishery Releases (IFR) or Language Services Daily (LSD) reports produced by the Office of International Fisheries Affairs, National Marine Fisheries Service, NOAA, Washington, DC 20235.

Norwegian Forsees Severe Problems for Cod Stocks

The cod fisheries in the entire North Atlantic area are on the way to catastrophe, a Norwegian scientist predicts. The last two recorded strong year classes—1973 and 1975—are in the process of being out-fished already before they have reached maturity. All in all, the stocks are reduced by an entire 80 percent, according to Norinform, the Norwegian Information Service.

This was predicted by marine researcher Arvid Hylen at the Institute of Marine Research in Bergen, after having participated in a long-term research trip in the area. On the trip, Hylen ascertained that 1980 was also a very poor year class.

The severe overtaxing of the year classes 1973 and 1975 has created a very serious situation, says Hylen, who claims that trawl fishing has, to a much

too large extent, concentrated exactly on these two year classes; he forecasts a considerable shortage of cod moving toward Lofotbankene in north Norway in years to come.

The entire resources situation was to be taken up at a meeting of the International Council for the Exploration of the Sea (ICES) in Copenhagen in October. As soon as possible, the mesh width of trawling nets should be effectively increased in order to hinder over-fishing of small fish, Hylen recommended.

Until 1975, 850,000 t of cod per year were caught by Norwegian fishermen in the North Atlantic area. In 1979, the quota was reduced to 700,000 t, but only 425,000 t were caught. Hylen says that the strength of the existing year classes of cod in the area is today only one-fifth of what it was previously, and he emphasizes the enormous problems this creates for both the fisheries and the fish-processing industry. This pattern of overtaxing must be changed, he says.

Canada Moves to Curtail Foreign Catch Misreports

Foreign fishing vessels convicted of misreporting their catches in Canada's 200-mile fishing zone now face increased penalties, Fisheries and Oceans Minister Roméo LeBlanc has announced. He said that the department has implemented more stringent measures to deal with misreporting violations by foreign fishing vessels licensed to operate in the Canadian 200-mile zone.

"Misreporting of catches could seriously undermine the management of the fishery and cause severe damage to the fish stocks we're trying so hard to rebuild," said the Minister.

Seven charges of misreporting of catches had been laid in the courts by late September 1980 by the Department of Fisheries and Oceans. In one case, a foreign captain, convicted of misreporting his catch by some 90 tons, was fined $2,000 and had his excess catch confiscated.

Foreign vessels fishing in Canada's 200-mile zone are inspected regularly to ensure their compliance with Canadian licence requirements. Charges of misreported catches have usually been based on estimates by Fisheries inspectors while on board the vessels, which are then brought to port for inspection and measurement by experts in this field.

To bring misreporting practices under control, the new measures provide that when a cargo of salted fish is involved, the entire cargo may be subject to offloading to establish accurately the amount on board, and to obtain evidence for trial. It is difficult to estimate the weight of salted fish since the volume of the fish shrinks at each stage of the curing process.

When court proceedings have been initiated for the misreporting of any species of fish, the Crown may press for confiscation of the entire catch on board, rather than only the alleged amount misreported, said LeBlanc.

If a captain has been convicted of misreporting a catch, the licence to operate his vessel in the Canadian zone will be cancelled for the remainder of the year in which the offense was committed, and no licence will be issued for the following year.

Canadian Fisheries Adopts Metric Units

It probably won't matter to the fish, but fishing in Canada is taking on a metric look. It matters to the fishermen, however, for they'll be measuring weight in kilograms instead of pounds; temperature in Celsius instead of Fahrenheit; and capacity in liters instead of gallons.

Most distance measurements will also be in kilometers instead of miles, but surface distance on navigational charts will continue in nautical miles; the 200-mile zone will remain in miles; and marine weather forecasts will continue in knots (nautical miles per hour).

Canada has adopted the metric system along with 98 percent of the countries of the world who are either now metric or who are converting to it. The metric system is considered important for continued Canadian exports to these countries.

Japan's Early 1980 Fish Imports Down 18 Percent

Japan's imports of fishery products during the first 6 months of 1980 amounted to 361,115 metric tons (t) valued at ¥ 301,216 million ($1,287 million at ¥ 234 = US$1) on a customs clearance basis, according to the Finance Ministry of Japan. This is a decrease of 18 percent in quantity from the same period last year.

By species, jack mackerel and salted herring roe imports dipped heavily. Jack mackerel at 1,141 t were down 92 percent from the comparable 1979 imports of 11,880 t, while salted herring roe at 1,717 t were down 2,431 t or 58 percent. Salmon imports for the period declined by 30 percent in quantity and 27 percent in value. Imports of salmon roe declined as much as 54 percent from the 1979 record to June. Imports of Alaska pollock roe only totaled 44 percent of the comparable 1979 level.

On the upside, herring imports to June 1980 rose 1.9 times to 16,081 t from last year's 8,100 t. Imports of Spanish mackerel, at 3,808 t, were up 32 percent. Live adult eel imports increased to 7,793 t, up 26 percent over the comparable 1979 period.

Meanwhile, 1980 shipments of air-freighted fresh "jumbo" bluefin tuna from the U.S. east coast to Japan reportedly totaled only about 100 fish to the end of July, approximately one-third of the total shipments for the same period last year. The decrease was due in part to high exvessel prices and in part to stagnant wholesale prices.

Exvessel prices on the U.S. east coast began at around $2.20/pound in late June and rose to $2.50/pound in mid-August. Wholesale prices at the Tokyo Central Wholesale Market on August 11 were reported to be between a high of ¥ 2,500/kg ($5.09/pound at ¥ 223 = US$1) and a low of ¥ 1,300/kg ($2.64/pound), averaging around ¥ 1,800/kg ($3.66/pound). The break-even prices currently accepted among the Japanese importers are $2.50/pound for exvessel price and ¥ 2,800/kg ($5.70/pound) for wholesale price. (Source: FFIR 80-8.)

New NMFS Scientific Reports

NOAA Technical Report NMFS Circular 424. Smith, David G. **"Guide to the leptocephali (Elopiformes, Anguilliformes, and Notacanthiformes)."** July 1979. 39 p.

Abstract

Elopiform leptocephali have a large, forked caudal fin, and nonconfluent dorsal and anal fins. Anguilliform leptocephali have a small, rounded caudal fin confluent with the dorsal and anal fins and lack pelvic fins at all stages of development. In the Anguilliformes, larvae of the Macrocephenchelyidae, Myrocongridae, and the subfamily Simenchelyinae of the Synaphobranchidae are unknown, and five distinctive kinds of leptocephali cannot be identified to family. Notacanthiform leptochphali are extremely elongate, have a single caudal filament rather than a true caudal fin, and have a short dorsal fin. Three kinds of notacanthiform larvae are known (*Tiluris*, *Tiluropsis*, and *Leptocephalus giganteus*) that cannot yet be identified below the ordinal level.

NOAA Technical Report NMFS Circular 426. Bigford, Thomas E. **"Synopsis of biological data on the rock crab, *Cancer irroratus* Say."** May 1979. 26 p.

Abstract

The rock crab, *Cancer irroratus* Say, is a common member of the benthic community along the east coast of North America. The species inhabits sandy bottom areas but may occur on gravel or rocky substrates. Bottom trawls and trapping via pots frequently yields high numbers of rock crabs. A growing market may create an increased demand for this underexploited species.

Cancer irroratus typically occurs from Labrador south to Florida. Within this range the crab is distributed in specific patterns with respect to temperature, salinity, depth, substrate, and time of year. Many of these factors, plus light, pressure, and gravity, affect larval distributions.

The literature includes several papers in general life history. Patterns of molting and growth have been studied in the laboratory and field for all of the life stages. Larval development and responses to environmental variables are also well described.

NOAA Technical Report NMFS Circular 427. Goulet, Julien R., Jr., and Elizabeth D. Haynes (editors). **"Ocean variability in the U.S. fishery conservation zone, 1976."** July 1979. 22 papers, 362 p.

NOAA Technical Report NMFS Circular 428. Kendall, Arthur W., Jr. **"Morphological comparisons of North American sea bass larvae (Pisces: Serranidae)."** August 1979. 50 p.

Abstract

Larvae of 17 of the 23 nominal genera of American serranid fishes are described. Representatives of only two of these genera have been described previously from American waters. The genera fall into four groups which closely follow subfamilial groupings based on adult characters. Larvae of the Serraninae, representing seven genera, appear to be the most generalized and are most similar to *Morone*-like percichthyid larvae. They have some larval specializations but exhibit rather direct development of adult morphology. The serranine genera can be ranked in order of increasing larval specialization as follows: *Serraniculus, Paralabrax, Centropristis, Diplectrum*, and *Serranus*. *Hypoplectrus* and one type of *Diplectrum*, although considered serranines on the basis of adult characters, are quite different from the other serranine larvae observed. One line of divergence from the serranines is the Anthiinae, with larvae of four genera being represented in the present collections. These larvae have variously developed strong spines on the head and in the opercular region, also the pelvic fin spine and some dorsal fin spines are strong and develop precociously. These spines are serrated in more specialized genera. Among the anthiine genera described there is a progression of larval specialization as follows: *Plectranthias, Pronotogrammus, Anthias*, and *Hemanthias*. A third general type of serranid larvae is represented by members of the three American genera of the Epinephelinae and *Gonioplectrus*. These larvae all are similar in general appearance and specialized in having elongate, strong serrate spines—primarily the second spine of the dorsal fin and the pelvic spine. The fourth larval type is comprised of three genera whose affinities have been unclear. *Liopropoma* is generally considered by others to be a serranid of the subfamily Liopropominae, *Pseudogramma* has been placed by others in the family Pseudogrammidae, or considered to be a member of a subfamily of the Grammistidae, the family in which *Rypticus*, the third genus, is placed. Because of the similarity of their larvae and evidence from adult characters, I consider these genera to be members of the serranid subfamily Grammistinae. Larvae of these genera share some larval characters with the serranines. Their most outstanding larval feature is the development of one or two greatly elongated flexible dorsal fin spines.

NOAA Technical Report NMFS Circular 429. Yoshida, Howard O. **"Synopsis of biological data on tunas of the genus *Euthynnus*."** October 1979. 57 p.

Abstract

Biological and fisheries data on *Euthynnus affinis, E. alletteratus*, and *E. lineatus* from published and unpublished sources were compiled, synthesized, and summarized following the FAO species synopsis outline.

The Fishes of Washington and Alaska

"Inland Fishes of Washington," by Richard S. Wydoski and Richard R. Whitney, has been published by the University of Washington Press, Seattle, WA 98105. It is the first such book for that State readily available to the general public (paper, $8.95; hardbound, $17.50), and combines scientific accuracy with excellent illustrations, and a well-written text.

First, the authors describe the State's topography, geology, and major drain-

ages, emphasizing aspects which influence distributions of fish species and the major types of aquatic habitat in the state. The next section provides instruction in basic fish identification and gives a key to the families of fishes.

The authors are, respectively, with the National Fisheries Center, Kearneysville, W. VA, (formerly with the Washington Cooperative Fishery Research Unit), and professor of fisheries at the University of Washington and leader, Washington Cooperative Fishery Research Unit.

The body of the book consists of keys and life histories of the 76 species of freshwater and anadromous fishes in the state, each illustrated by a color photograph of a typical specimen. Each photograph was carefully set up and taken for accuracy and consistency. Descriptions contain capsule information on distribution, habitat, age and growth, reproduction, foods and feeding, and significance of the species. Also included is a summary of those species occurring in Oregon and Idaho which are not treated in the text.

Families represented include Petromyzontidae, Acipenseridae, Clupeidae, Salmonidae, Osmeridae, Umbridae, Esocidae, Cyprinidae, Catostomidae, Ictaluridae, Poeciliidae, Gadidae, Gasterosteidae, Percopsidae, Percichthyidae, Centrarchidae, Embiotocidae, Perdicae, Cottidae, and Pleuronectidae.

The 274-page volume has an extensive bibliography and a glossary. Appendixes also provide data on state and selected world record fish, the photographic techniques used to illustrate the volume, and a checklist of Oregon and Idaho fishes not included in the text. Though its references to strictly marine species are limited, its data on anadromous and freshwater species are very useful.

Publication of **"The Freshwater Fishes of Alaska"** has also been announced by Alaska Northwest Publishing Company, 130 Second Avenue South, Edmonds, WA 98020. The 248-page paperbound 8½ × 11 inch volume was written by James E. Morrow, professor emeritus of the University of Alaska, and former chairman of the University's Department of Biological Sciences, and a former ichthyological editor of *Copeia*. It was illustrated by Marion Dalen, a former illustrator for the Smithsonian Institution. Several years in the making, the volume includes text and illustrations for all 56 species of fish that inhabit—or enter—the freshwater rivers, lakes, and streams of Alaska. It also contains an excellent bibliography and a glossary of terms.

The introduction gives a brief rundown on classification and nomenclature of fishes, common measurements, ageing of fishes, and a brief key to the families treated: Petromyzontidae, Acipenseridae, Clupeidae, Salmonidae (separate chapters for Coregoninae, Salmoninae, and Thymallinae), Osmeridae, Umbridae, Esocidae, Cyprinidae, Catostomidae, Percopsidae, Gadidae, Gasterosteidae, Embiotocidae, Cottidae, and Pleuronectidae. Each chapter begins with a key to the Alaskan species in the particular family, followed by data on distinctive characters (description), range and abundance, habits (biology/life history) and the species' "importance to man."

Numerous line drawings show each species and map its range. These are supplemented by 65 color photographs, and 17 color and 13 black and white illustrations. Three other series of photographs (b&w) illustrate breeding behavior of the Arctic charr, northern pike, and fourhorn sculpin. The book will be useful to anyone interested in the freshwater and anadromous fishes of Alaska. It is available from the publisher for $24.95 plus $0.75 for postage and handling.

Farming Mussels in North America

"Mussel Culture and Harvest: A North American Perspective," edited by Richard A. Lutz, has been published by Elsevier Scientific Publishing Company, P.O. Box 211, Amsterdam, The Netherlands, and 52, Vanderbilt Ave., New York, NY 10017. It is Volume 7 in the publisher's "Developments in Aquaculture and Fisheries Science" series.

The volume introduces the feasibility of mussel culture in North America, lists recent research efforts and tells the advantages of a cultured mussel in Chapter 1. Chapter 2 provides a historical review of U.S. mussel culture and harvest while the third chapter reviews natural mussel stocks: Their growth, recruitment, and harvest potential. Chapter 4 reviews European mussel culture technology (i.e., bouchot, bottom, and raft and longline culture) and their adaptability to North American waters.

In Chapters 5 and 6, researchers provide a perspective on U.S. east coast and west coast mussel culture, respectively. Succeeding chapters discuss mussel culture in heated effluents, pearl incidence in mussels, accumulation of algal biotoxins in mussels, storage and processing of mussels, evolution of a commercial mussel culture operation, and discusses some economics of mussel culture and harvesting.

The authors of each chapter are experts in their field and the volume will be valuable to anyone interested in mussel culture. The 350-page book costs $65.75 and is available from the publisher.

Alaskan Seafood Business Profiled

JAI Press, P.O. Box 1678, Greenwich, CN 06830, has announced publication of **"Pioneering a modern small business: Wakefield Seafoods and the Alaskan frontier,"** by Mansel Blackford, as the sixth volume in its series titled Industrial Development and the Social Fabric.

Chapters discuss the company's formative years (1945-52), the years of its expansion (1953-63) in the king crab fishery and processing, and the years of decision (1964-68). Another chapter explores "The company in politics" while the final chapter concludes that the company typifies the evolution of other small businesses that succeed. The scholarly volume is well written and contains extensive footnotes and a bibliography. It is available from the publisher for $24.50.

Editorial Guidelines for *Marine Fisheries Review*

Marine Fisheries Review publishes review articles, original research reports, significant progress reports, technical notes, and news articles on fisheries science, engineering, and economics, commercial and recreational fisheries, marine mammal studies, aquaculture, and U.S. and foreign fisheries developments. Emphasis, however, is on in-depth review articles and practical or applied aspects of marine fisheries rather than pure research.

Preferred paper length ranges from 4 to 12 printed pages (about 10-40 manuscript pages), although shorter and longer papers are sometimes accepted. Papers are normally printed within 4-6 months of acceptance. Publication is hastened when manuscripts conform to the following recommended guidelines.

The Manuscript

Submission of a manuscript to *Marine Fisheries Review* implies that the manuscript is the author's own work, has not been submitted for publication elsewhere, and is ready for publication as submitted. Commerce Department personnel should submit papers under completed NOAA Form 25-700.

Manuscripts must be typed (double-spaced) on high-quality white bond paper and submitted with two duplicate (but not carbon) copies. The complete manuscript normally includes a title page, a short abstract (if needed), text, literature citations, tables, figure legends, footnotes, and the figures. The title page should carry the title and the name, department, institution or other affiliation, and complete address (plus current address if different) of the author(s). Manuscript pages should be numbered and have 1½-inch margins on all sides. Running heads are not used. An "Acknowledgments" section, if needed, may be placed at the end of the text. Use of appendices is discouraged.

Abstract and Headings

Keep titles, heading, subheadings, and the abstract short and clear. Abstracts should be short (one-half page or less) and double-spaced. Paper titles should be no longer than 60 characters; a four- to five-word (40 to 45 characters) title is ideal. Use heads sparingly, if at all. Heads should contain only 2-5 words; do not stack heads of different sizes.

Style

In style, *Marine Fisheries Review* follows the "U.S. Government Printing Office Style Manual." Fish names follow the American Fisheries Society's Special Publication No. 6, "A List of Common and Scientific Names of Fishes from the United States and Canada," third edition, 1970. The "Merriam-Webster Third New International Dictionary" is used as the authority for correct spelling and word division. Only journal titles and scientific names (genera and species) should be italicized (underscored). Dates should be written as 3 November 1976. In text, literature is cited as Lynn and Reid (1968) or as (Lynn and Reid, 1968). Common abbreviations and symbols such as mm, m, g, ml, mg, and °C (without periods) may be used with numerals. Measurements are preferred in metric units; other equivalent units (i.e., fathoms, °F) may also be listed in parentheses.

Tables and Footnotes

Tables and footnotes should be typed separately and double-spaced. Tables should be numbered and referenced in text. Table headings and format should be consistent; do not use vertical rules.

Literature Citations

Title the list of references "Literature Citations" and include only published works or those actually in press. Citations must contain the complete title of the work, inclusive pagination, full journal title, the year and month and volume and issue numbers of the publication. Unpublished reports or manuscripts and personal communications must be footnoted. Include the title, author, pagination of the manuscript or report, and the address where it is on file. For personal communications, list the name, affiliation, and address of the communicator.

Citations should be double-spaced and listed alphabetically by the senior author's surname and initials. Co-authors should be listed by initials and surname. Where two or more citations have the same author(s), list them chronologically; where both author and year match on two or more, use lowercase alphabet to distinguish them (1969a, 1969b, 1969c, etc.).

Authors must double-check all literature cited; they alone are responsible for its accuracy.

Figures

All figures should be clearly identified with the author's name and figure number, if used. Figure legends should be brief and a copy may be taped to the back of the figure. Figures may or may not be numbered. Do not write on the back of photographs. Photographs should be black and white, 8- × 10- inches, sharply focused glossies of strong contrast. Potential cover photos are welcome but their return cannot be guaranteed. Magnification listed for photomicrographs must match the figure submitted (a scale bar may be preferred).

Line art should be drawn with black India ink on white paper. Design, symbols, and lettering should be neat, legible, and simple. Avoid freehand lettering and heavy lettering and shading that could fill in when the figure is reduced. Consider column and page sizes when designing figures.

Finally

First-rate, professional papers are neat, accurate, and complete. Authors should proofread the manuscript for typographical errors and double-check its contents and appearance before submission. Mail the manuscript flat, first-class mail, to: Editor, *Marine Fisheries Review*, Scientific Publications Office, National Marine Fisheries Service, NOAA, 1700 Westlake Ave., N., Room 336, Seattle, WA 98109.

The senior author will receive 50 reprints (no cover) of his paper free of charge and 100 free copies are supplied to his organization. Cost estimates for additional reprints can be supplied upon request.

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